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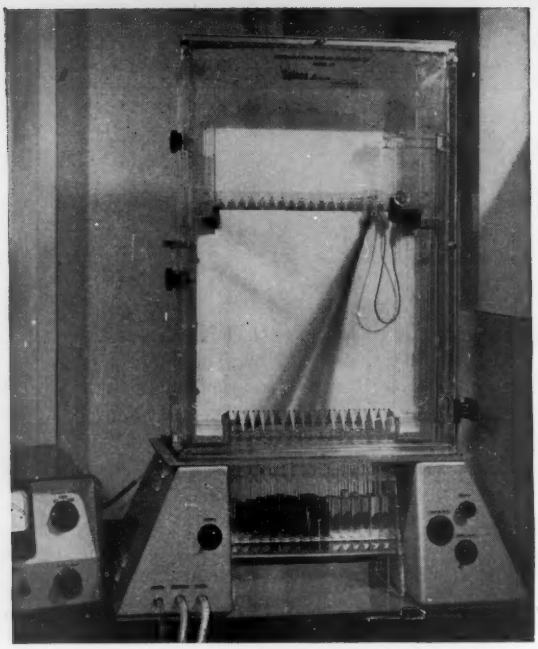

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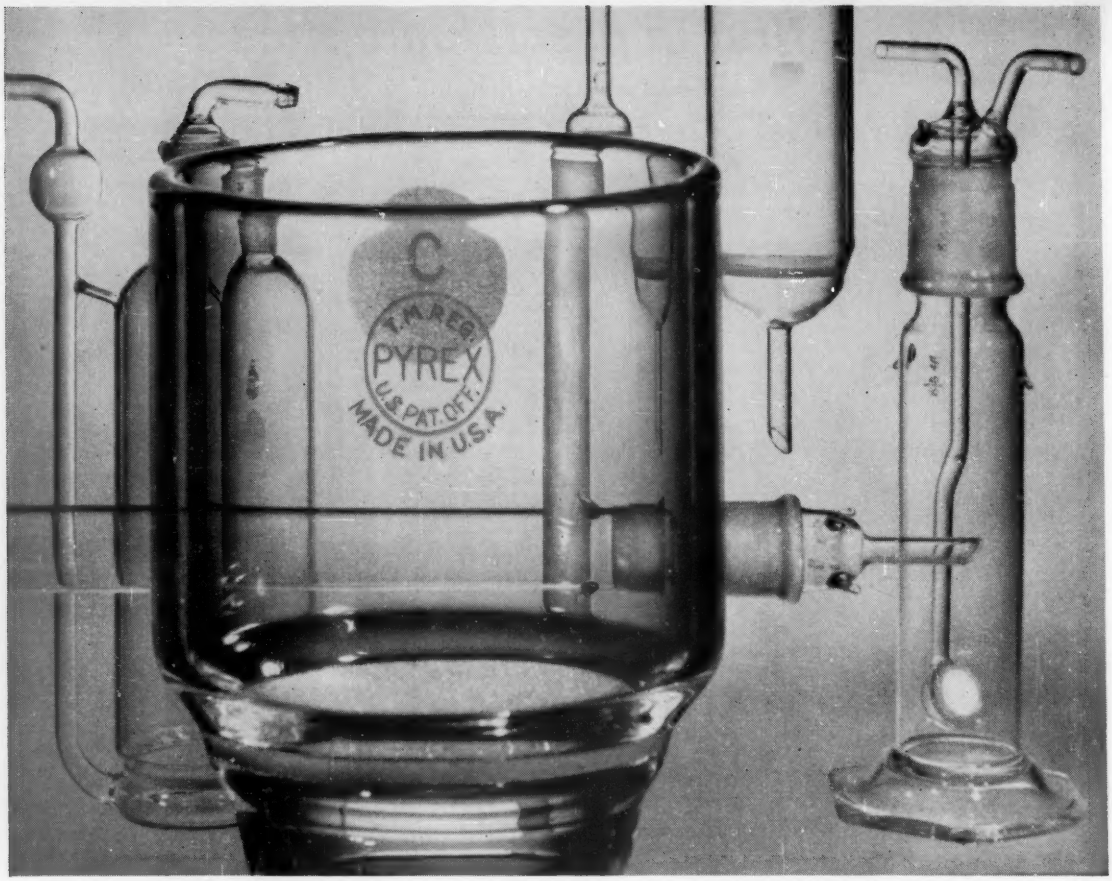

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The National Committee

The National Committee for the Development of Scientists and Engineers took a long time to get appointed [*Science* **123**, 662 (20 Apr. 1956)] but has gotten off to a fast start on a program of activities. The committee met first on 15 May and again on 21–22 June. At its first meeting the committee decided to give immediate attention to two problems: the number, training, qualifications, and utilization of technical aides to scientists and engineers; and the improvement of elementary- and secondary-school education in science and mathematics. Working groups were appointed to study these problems. At the second meeting of the committee, both groups presented concrete recommendations of actions to be taken by the various citizens' groups and agencies that are in a position to take effective action.

The committee differs from most federal committees in three important respects: it was appointed for an indefinite, rather than a limited, period of time; its membership consists not of individuals appointed as such but of the presidents or heads of organizations that can contribute directly to the problem of securing better scientific education and more and better qualified scientists and engineers; and, the committee is not primarily advisory to the Federal Government but rather to the represented organizations and the country at large. As the President stated in appointing the committee, ". . . although the government has a responsibility for increasing the supply and improving the quality of our technological personnel, the basic responsibility for solution of the problem lies in the concerted action of citizens and citizens' groups organized to act effectively."

Accordingly, the committee consists of the presidents of the AAAS, the National Academy of Sciences, the National Science Teachers Association, the Engineers Joint Council, the National Education Association, the Governors' Conference, the U.S. Chamber of Commerce, and other educational, managerial, and governmental organizations.

With the spotlight shining so brightly on science and engineering, it may happen that overenthusiastic or ill-planned efforts to aid those fields may adversely effect other fields. This danger must be avoided. The AAAS board of directors has asked President Paul Sears to convey to the committee the Association's concern that the interests of society as a whole be kept uppermost in mind, and that actions concerning science and engineering be considered in this light.

There are several reasons why it is appropriate to give special attention to science and engineering. The role of no other major segment of society and industry is changing so rapidly. In periods of rapid growth special problems of manpower supply, of education, and of public understanding are almost inevitable. The scientist's role in military strength, and hence in this country's position vis-a-vis the Soviet Union, gives added and pressing reason for paying special attention to science and engineering.

These reasons justify the appointment of the National Committee and the attention that will surely be given to its recommendations. But they do not mean that science and engineering are more important than are other areas of professional or scholarly endeavor. On the contrary, they increase scientists' responsibility to keep the emphasis undistorted and to make every effort to maintain proper balance with other fields of endeavor.
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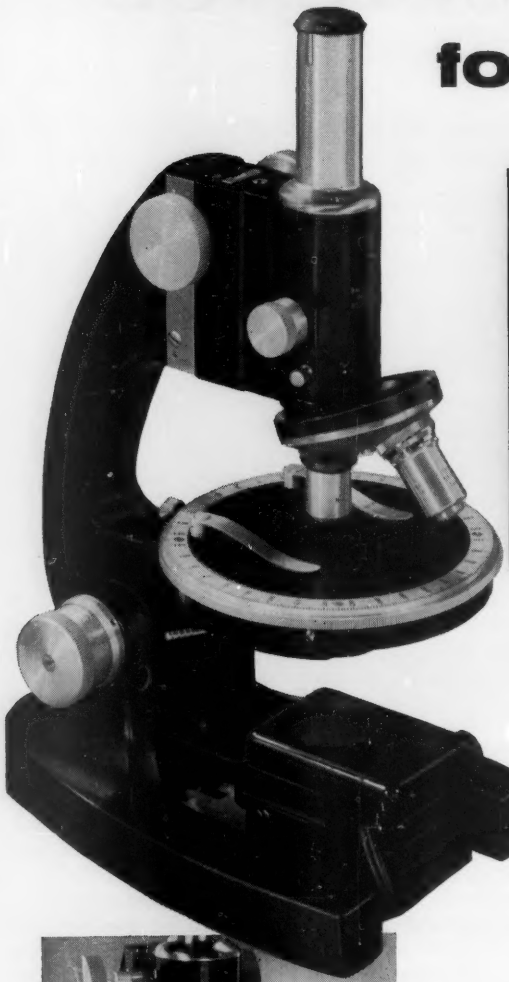

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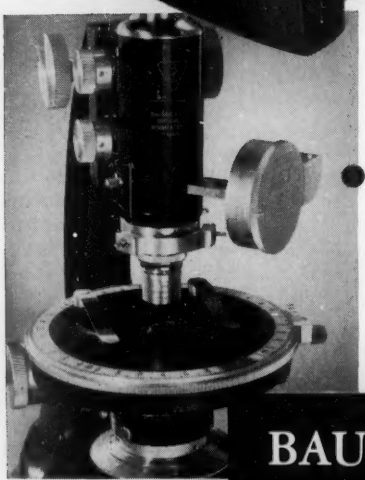

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Equilibrium Diagrams and Single Crystal Growth

Samuel Zerfoss

The crystal grower is a specialist who operates at the second step of a chemical preparation experiment. The first step is the synthesis of the compound; it yields polycrystalline material of varying degrees of fineness. In this step the chemist has been quite successful. Among naturally occurring compounds (minerals), only a short list remains to be synthesized.

The second step of the experiment is the conversion or ordering of the polycrystalline synthetic product into a single crystal. An even higher level of operation may be superimposed on this experiment in that not only must the crystal be single (*1*) but it must also be chemically homogeneous and possess a high degree of perfection. As operations go in the laboratory, step 1, synthesis, is easy; step 2, single crystal growth, advances satisfactorily; but step 3, perfection, is a matter of extreme difficulty. For practical laboratory reasons, one must grow crystals under conditions that depart from equilibrium ones. It is the purpose of this discussion (*2*) to relate the data of equilibrium as illustrated in the phase equilibrium diagrams (*3*) to the possibility of single crystal growth.

Figure 1 shows an idealized binary phase equilibrium diagram with two compounds (one melting incongruently), two eutectics, and one peritectic. The liquidus line (*ABCOEG*), under equilibrium conditions, is the locus of all points of liquid-solid equilibria. Crystal growth from the melt requires operating, under conditions of supersaturation, at some temperature below this liquidus. This set of conditions is not known but must be fixed by trial and error, usually by setting up a thermal gradient, the sharp region of which contains the liquidus isotherm. The points marked *A*, *C*, and *G* (Fig. 1) are congruent melting points of compounds. These points represent compositions ideal for crystal growth by either the crucible lowering or the withdrawal method. While one can never be certain of achieving the exact diagram composition, small deviations are apparently permissible (near 1 percent). Deviations from the true stoichiometry characteristic of the compound are also allowed.

Compositions on this diagram will be related to growth from the melt by three methods, (i) the crucible method, (ii) the withdrawal method, and (iii) the flame fusion method.

Crucible Method

In the crucible method, a cylindrical crucible with a cone-shaped tip containing the melt is lowered through a furnace in which there is established a sharp thermal gradient. As the tip of the cone passes through that isotherm near the liquidus of the melt (some isotherm below the melting point within the region of metastable supersaturation), it is hoped that one nucleus will form to the exclusion of others and that, with further lowering, this nucleus will grow to fill the crucible with one crystal. Thus the method is an attempt to depart from normal freezing to a polycrystalline ingot by inducing nucleation in a small volume of melt.

The sharpness of the thermal gradient in the critical region of phase change and the rate of lowering are two important physical factors for obtaining single crystals. Although these factors have been recognized, their respective contributions have not yet been analyzed (*4*). It is common experience that lowering the crucible too rapidly will yield an ingot with a single-crystal skin and a polycrystalline interior or pipe. The thermal gradient and the rate of lowering are the heat sink for extraction of the energy change of freezing, and this part of the operation fails if either is inadequate.

From a chemical point of view, a truly one-component system with congruent melting point (and no lower inversions) is desired. To maintain this desirable chemical composition there must be no chemical contribution from the atmosphere (oxidation-hydrolysis) or from the crucible (thus insuring a one-component system). A second solid phase, scum, or oxidation products offer undesirable and uncontrollable points of local nucleation.

So far only one-component melts have been considered. Another different composition on the diagram is the isopleth *D* (Fig. 1). A melt of this composition yields, on cooling, crystals of XY_n. Below the liquidus (*CB*), these crystals are in equilibrium with a mother liquor whose composition varies with temperature. The composition of this liquid at any temperature is given by the intersection of the isotherm with the liquidus *BC*. Final solidification takes place at *B*. On cooling, this liquid crystallizes as XY_n, and the liquid is enriched in *X*.

Some idea of the influence of impurities (solid solution) on the ease of growth of single crystals is available from the work of Goss (*5*). Goss added known amounts of antimony, cadmium, lead, zinc, silver, and indium to 99.997-percent tin and grew crystals from these melts. The influence of the impurities on the texture was a function of the amount of addition. For a melt where the addition was 0.1 percent of the solid solubility limit, it was not possible to obtain single crystals under conditions of rapid growth. Single crystals could be obtained at slower growth rates, but they had marked superstructure. When the level of impurity was 0.01 percent of the solid solubility limit, there was no effect on the ease of growth of single crystals, but there was a continual effect on the texture. Crystallization of XY_n from such a liquid is very significantly different

The author, formerly a chemist in the Crystal Branch of the U.S. Naval Research Laboratory, is now chief of the Refractories Section, Mineral Products Division, National Bureau of Standards.

from crystallization from its own melt in that the solid phase is in equilibrium with a liquid of constantly varying composition. It is true that the liquid is always crystallizing XY_n, but the environment in the neighborhood of the growing face of crystal XY_n is a varying one, and hence the crystal growth may become diffusion-controlled. In addition, the nucleation process is forced into a different environment. Attempts at U.S. Naval Research Laboratory to grow single crystals of such binary melts by the crucible method have been uniformly unsuccessful. The isopleth *F* (Fig. 1) presents the third type of melt on this diagram. This composition, on cooling to the liquidus *EG*, yields crystals of *Y*. On further cooling, *Y* continues to crystallize out, the liquid changing in composition along *EG* toward *E*. When the composition *E* is reached, an isothermal reaction occurs. $Y + \text{liquid} = XY_m$ and for composition *A* final crystallization takes place, yielding a single phase XY_m. Conversely, XY_m melts incongruently to yield $Y + \text{liquid}$.

Such a composition as *A* does not lend itself to single-crystal growth by the crucible-lowering method. Successful completion of the liquid-solid reaction under the conditions of growth would be nearly impossible. The crucible method can be operated using an oriented seed in the tip with considerable difficulty of control. The orientation of the single crystal obtained by the usual spontaneous nucleation in a cone tip is a function of (i) thermal gradient, (ii) rate of lowering, and (iii) the principal growth direction of the phase. The particular function is as yet unknown.

Withdrawal Method

In the withdrawal or Kyropoulos method, one uses a stationary crucible placed in an open furnace, thereby providing a thermal gradient above the melt. A cold finger is lowered into the melt to initiate crystallization. The resultant crystal mass on the cold finger is withdrawn from the melt by an elevator. This initial mass can be made up of several crystals. In the withdrawal method, this mass from within the melt was raised until the smallest contact was made with the surface of the melt (hopefully a single-crystal contact). Then, by adjusting the gradient slightly, we allowed this contact to widen to a larger diameter and then grow. In effect, then, a portion of the initial polycrystalline mass seeded the melt. Of course, in practice, one commonly uses single-crystal seeds held in a chuck on the cold finger.

The composition limitations of the crucible and withdrawal methods are quite similar. Compositions *A*, *C*, and *G* (Fig. 1) can be grown with ease. Growth of compositions such as XY_m have not been reported but are probably possible between points *E* and *O* (Fig. 1). Recent studies have been made of the growth of crystals from compositions such as *D* (Fig. 1).

A recent attempt by Pankove (*6*) to grow germanium from an indium-germanium melt was also unsuccessful; it resulted in a type of epitaxial growth (myriads of commonly oriented dendrites of germanium on the germanium seed). Such dendritic growth could be explained on the basis of too-rapid growth and/or inadequate agitation (diffusion-controlled growth).

Carman *et al.* (*7*) grew a silicon crystal from a silicon-gold eutectic melt using a zone-melting technique. In a horizontal boat, they arranged in order a silicon crystal seed, the eutectic melt (6 percent Si at 370°C), and a quantity of silicon across the boat. A narrow zone of eutectic melt (achieved by using a single coil of an induction heater) joined the silicon seed and the source material. Within this zone, silicon was dissolved from the source material and deposited on the seed. By moving the zone at a rate of 0.001 inches per hour, they grew a crystal. In this experiment, apparently, conditions for good diffusion with the zone and on the growing face must have been present.

Crystal growth from water solution is accomplished from compositions identical with isopleth *D* (Fig. 1). Successful growth is obtained by providing proper control of agitation and supersaturation. It is evident that failure to obtain good growth from such compositions as *D* (Fig. 1) for higher temperature melts must be explained on the basis of inadequate controls.

Some water-soluble crystals are difficult to grow from water solution—for example, the alkali halides (NaCl). Their solutions are characterized by poor supersaturation. Growth of the alkali halides can be catalyzed by the use of additives (*8*).

Flux Melt Growth

Composition *D* (Fig. 1), although it is not ideally suited to growth by the crucible or withdrawal method, was used as early as 1823 by Berthier for growth of small crystals of the pyroxenes and olivines. If one can find a low-melting compound such as the alkali halides, borates, boron oxide (B_2O_3), and so forth which form a eutectic with a refractory compound, then, by suitable choice of composition *D* (Fig. 1), it is possible to obtain recrystallization of the refractory compound.

In practice, one would pick a composition yielding the desired compound as the primary phase (in the field *BCO* of Fig. 1, XY_n is the primary phase for all compositions), which is allowed to nucleate XY_n and then is slowly cooled, allowing the nuclei of XY_n to grow to the solidus *1BI*, when all liquid would be solidified.

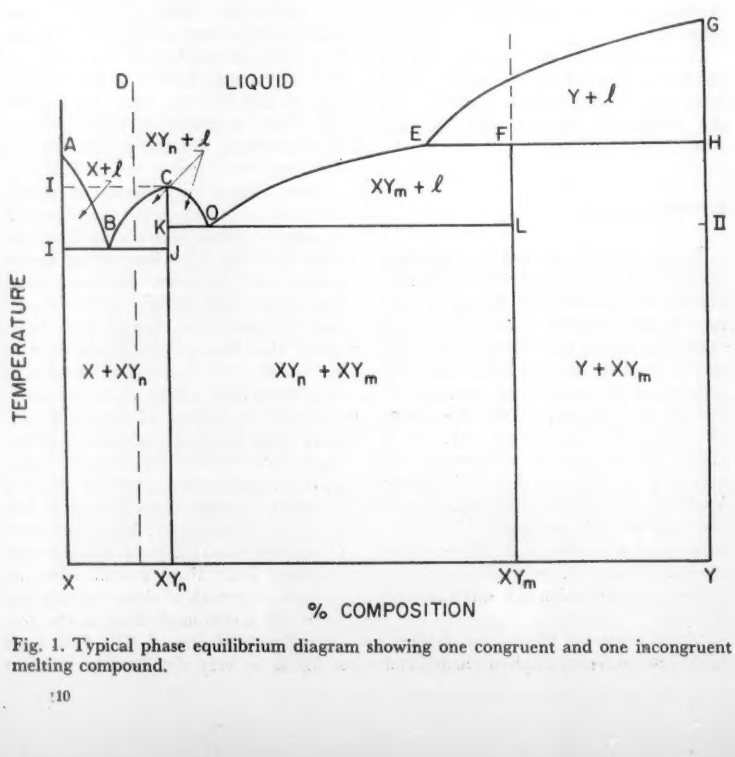

Fig. 1. Typical phase equilibrium diagram showing one congruent and one incongruent melting compound.

Weyl (*9*) used potassium chloride (KCl) to recrystallize magnesioferrite ($MgFe_2O_4$). There are numerous other uses of fluxes in industry to recrystallize refractory compounds.

Nepheline ($NaAlSiO_4$) is not in equilibrium with its own melt and hence cannot be grown directly from a dry melt. Winkler (*10*) has used lithium fluoride (LiF) as a flux to produce single crystals of nepheline. The LiF-nepheline system is not a simple eutectic. However, a melt can be chosen which yields nepheline as a primary phase. The resulting crystals were imperfect and contained numerous inclusions.

Attempts to grow tetragonal barium titanate ($BaTiO_3$) from its own melt have been unsuccessful, apparently because of the existence of higher polymorphic forms. Remeika (*11*) has succeeded in growing tetragonal $BaTiO_3$ from a potassium fluoride (KF) melt. The $BaTiO_3$-KF system has been shown to be a simple eutectic system. In practice Remeika used a batch of 30-percent $BaTiO_3$ and, after soaking the melt at 1150 to 1200°C for 8 hours to effect solution, he cooled the melt slowly to 850°C to effect crystallization. Separation of crystal and melt can be made by decantation of the supernatant melt or subsequent water extraction when cold. The yield consisted of crystal plates of $BaTiO_3$ up to 1 square centimeter in area.

Three considerations enter into the choice of flux: (i) The necessary solubility (eutectic relation between compound and flux) between flux and refractory constituent at temperatures yielding the desired phase. Thus, in the case of $BaTiO_3$ previously cited, the growth took place in the neighborhood of 1200°C within the field of stability of the tetragonal polymorph. Growth from its own melt yielded a higher temperature polymorph. (ii) Absence of reaction or solid solution between flux and compound. In the LiF-nepheline system a proper choice of composition must be made since the system contains another binary solid phase. Attempts at the Naval Research Laboratory to grow $MgFe_2O_4$ with B_2O_3 as the flux were unsuccessful. The attempt yielded a reaction product of a magnesium-iron borate not unlike natural ludwigite. Attempts at the Naval Research Laboratory to grow potassium bromide (KBr) crystals from a melt of potassium bromide and silver bromide (AgBr) (simple eutectic) yielded only cloudy crystals. Although the KBr-AgBr is reported as a simple eutectic system, there is a trace of solid solution at the liquidus; this solid solution unmixes on cooling to give a clouded crystal of KBr. (iii) It is desirable to be able to separate crystals from eutectics after growth; hence a water-soluble flux is ideal. These considerations are another way of saying that a knowledge of the phase diagram is essential to complete success in flux melt growth.

In summary it must be repeated that growth by this method is largely diffusion-controlled since adequate stirring is rarely practical. Nucleation in this case is also quite a random process.

Flame Fusion Method

The Verneuil Method (*12*) (flame fusion) has been used to grow refractory compounds such as corundum (Al_2O_3), spinel ($MgAl_2O_4$) and rutile (TiO_2).

The source of heat is an oxyhydrogen torch. The method consists of passing the powder through the inner element of the torch. As the powder emerges into the flame, it is heated and collected on a refractory rod. By suitable manipulation, the mass of powder particles and liquid on the refractory rod are converted into a single crystal. A seed can also be used as the collecting rod.

As in the previously described crucible and withdrawal methods, the flame-fusion method requires that the crystal and melt be identical with respect to composition. With one exception, all crystals grown by this method have congruent melting points. The specification with respect to purity is extreme because the method does not lend itself to gross rejection of impurities during growth. Growth takes place on the thin skin of molten material atop the refractory support. If this liquid layer becomes clouded with foreign material rejected during crystallization, further addition of material is impeded and further good growth is halted. As the powders pass through the flame to their destination, they acquire heat but quite probably are not melted until contact with the growing surface is made. Then they melt and become part of the thin liquid layer on the growing crystal. This fusion and subsequent crystallization on the substrate takes place in an enormous thermal gradient. Only ideal chemical homogeneity permits single-crystal growth under these conditions.

Star sapphires have been produced by using a composition of Al_2O_3 with a trace of TiO_2 which is stable and homogeneous under the conditions of growth but which when annealed precipitates TiO_2. The precipitate, under controlled conditions, occurs on the principal crystallographic planes of the single sapphire crystal, thus yielding veils of TiO_2 oriented to present the optical star effect (*13*).

The case of spinel growth is complicated by the experience that it is difficult to grow $MgAl_2O_4$ on composition. This difficulty is reduced by growing the solid solution of $MgAl_2O_4$-Al_2O_3 with compositions up to 80 mol percent Al_2O_3. The resultant crystal is not stable at room temperature since annealing at lower temperatures causes exsolution (precipitation) of Al_2O_3 (*14*). In an attempt to remove the strain, these crystals were annealed just below the liquidus and then quenched. In this procedure, the strain developed during growth was relieved without inducing exsolution. Rutile (TiO_2) has been grown by flame fusion. The resulting boule, although it is of rutile phase, is deficient in oxygen (TiO_{2-x}). It is opaque and has a high dielectric constant (*15*). Subsequent heating of the boule in O_2 at 1000°C will reduce the O_2 deficiency and return the boule to the transparent TiO_2. The oxidation-reduction process is reversible.

Scheelite ($CaWO_4$) and powellite ($CaMoO_4$) can be grown by flame fusion. However, if the feed material is on composition, growth is difficult since tungsten trioxide (WO_3) and molybdenum trioxide (MoO_3) are volatilized preferentially (*16*). Compensation for this volatization can be made by adding excess oxide to the feed. No solid-solution growth is involved in this case, and excess oxide over that required for stoichiometry is simply volatilized. Similar compensation must be made in the case of the growth of nickel and cobalt ferrites. In these cases ferric oxide (Fe_2O_3) is volatilized preferentially. Single crystals of these compounds can be grown but not on 1 to 1 molar composition. These ferrites can dissolve excess Fe_2O_3 in solid solution.

Bauer (*17*) has grown mullite ($3Al_2O_3 \cdot 2SiO_2$) by flame fusion. This is the only published example of an incongruent melting compound grown by flame fusion or other methods. The Al_2O_3-SiO_2 system has one compound mullite (72 percent Al_2O_3) melting incongruently at 1810°C to yield a liquid of 55 percent aluminum oxide (Al_2O_3) and crystals of corundum (Al_2O_3). The shape of the liquidus is like that of Fig 1 over XY_m.

Normally, when one cools a melt of mullite composition at a temperature of about 1950°C, crystallization occurs with corundum as the primary phase, as in the case of XY_m (Fig. 1). With further cooling, corundum continues to precipitate until the peritectic at 1810°C is reached, when, at constant temperature, resorption of corundum by the liquid takes place, yielding mullite. In the flame-fusion growth of mullite, this precipitation of the primary phase corundum is bypassed and mullite forms. This crystallization takes place in a thermal gradient of several hundred degrees per centimeter. Attempts at the Naval Research Laboratory to grow another in-

congruent melting compound, $3CaO \cdot Al_2O_3$ were unsuccessful. This compound differs from mullite in that the liquidus overhead rises very steeply so that the separation of liquidus and peritectic is about 165°C, whereas the separation in the case of mullite is 130°C. Perhaps a requirement for the mullite growth was the fairly flat liquidus curve and the smaller separation of liquidus and peritectic isotherms.

Solid Solutions

In the previous cases, the liquidus for the various systems was discontinuous—that is, interrupted by eutectics, compounds, or peritectics; the discontinuity defined areas of discrete phase stability. Another type of single-crystal growth involves cases where the liquidus is continuous and one phase—a solid solution—is in equilibrium. A typical diagram is given in Fig. 2. The liquidus and solidus lines are the loci of all compositions of liquid and solid in equilibium at any temperature. At T_1, a crystal of composition C_1 is in equilibrium with liquid C_1'. On cooling, the crystal first separating is richest in the more refractory phase. As cooling proceeds under equilibrium conditions, this first crystal must be made over by the liquid—dissolved and recrystallized—to attain the equilibrium concentration demanded by the new temperature condition. Thus, through a theoretical equilibrium cooling, the following sequence of steps would occur on cooling a composition X: (i) (T_1) first crystal of composition C_1 in equilibrium with liquid X; (ii) on cooling to T_2, crystal C_1 has dissolved and recrystallized to a crystal of composition C_2 (containing less A than C_1) while liquid X has lost A to become composition C_3'; (iii) (T_4) by this process, the last bit of liquid of composition C_4' is crystallized to yield a homogeneous solid-solution phase C_4.

Thus, under equilibrium conditions, the liquid of composition X is crystallized to a homogeneous solid of composition X. Failure of equilibrium crystallization will result in fractionation—the initial crystals will be richer in A; the final crystals richer in B. In terms of single-crystal growth, this will yield a chemically zoned crystal (cored) so commonly found among the natural feldspars, pyroxenes, and other minerals. From the standpoint of material for solid-state physical investigation, such a badly cored or zoned crystal is extremely undesirable. For example, if by the crucible method we start with a charge of 5 mol percent of AgCl in NaCl, the system AgCl-NaCl shows continuous solid-solution relation of the liquidus. If we grow such a charge, the resultant boule may be single but will have a composition at the tip of roughly 98 percent NaCl and, for example, along a 3-inch length will vary in composition continuously to 90 mol percent NaCl. Using the crucible or withdrawal technique as usually practiced, it is virtually impossible to obtain a chemically homogeneous, solid-solution single crystal. One unique exception to this statement is the case of KRS-5. The system thallium triiodide (TlI)-thallium tribromide (TlBr) forms a continuous series of solid solutions, but the liquidus shows a low melting minimum at 42 mol percent TlBr. Single crystals of this composition have been grown and shown to be homogeneous.

The solubility of a foreign ion or solute in a melt and in the solid phase in equilibrium with that melt on crystallization is usually not identical. Forces acting within the growing solid tend to deny access to all of the ingredients of the mother liquor. This phenomenon has been used for years in the purification or separation of closely allied materials. As in the previously mentioned case of NaCl-AgCl melts, the operation of crystal growth results in a disproportioning of the original homogeneous solution into a continuously chemically graded solid solution. By repeated growth of the extreme portions of such a chemically graded system, one could slowly purify a mixed melt of the solute just as one extracts soluble salts in an analytic filtration by washing with distilled water. Although the method of purification by crystal growth has been known for a long time, the refinement of the process has taken place with the advent of the growth of single-crystal germanium and the purification of germanium or silicon by zone refinement. Zone refining is a process involving the localized melting of a thin zone of an ingot and the movement of this melted zone slowly along the length of the ingot. In practice, one would melt the end of the ingot and then slowly move the zonal heat source (or the ingot) along the length, allowing the passed material to freeze. In this operation, if the impurity distribution is in the direction of the liquid (if the crystallized material rejects the impurity), then the liquid zone will accumulate the impurity naturally, and the impurity is segregated in the final zone. In a solid solution system, there is a distribution solid-liquid and complete sanitation is never achieved. This distribution is defined as the ratio of the concentration in the initial melt to the concentration in the first crystal, but it varies in an as-yet-unexplained fashion from ion to ion and host to host (*18*).

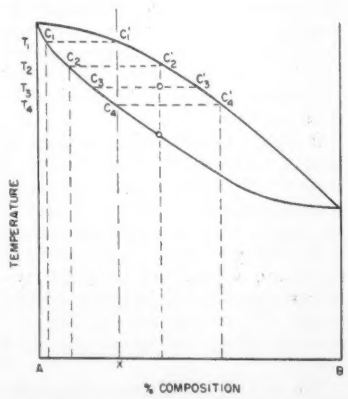

Fig. 2. Phase equilibrium diagram showing complete solid solution between the two components.

The result of the crystallization of a melt in a solid-solution system is a solid whose composition varies continuously from the initial crystal deposited to final exterior of the crystal. One can obtain a single crystal of widely varying composition interior to exterior (the initial freezing is richest in the more refractory constituent). If during the freezing there are times when near equilibrium is obtained, the resultant crystal will be made up of zones corresponding to these terms. These zones may in themselves be chemically homogeneous—for example, plagioclase, feldspars in granites, and so forth.

It is difficult to explain the large chemically homogeneous single crystals of solid solutions that one finds in nature, such as tourmaline, topaz, olivine, and others. Perhaps time alone is the explanation for such chemical perfection.

In the laboratory, it is extremely difficult to obtain an unzoned or chemically homogeneous solid-solution ingot or crystal. Recently, as a result of the work on germanium and silicon, a new concept of zone-leveling has been introduced. In the course of zone melting of a solid-solution ingot, the initial solid crystallizing out will differ markedly from the liquid. As the zone melting progresses, a point will be reached where liquid and solid have the same composition. This portion of the solidified ingot will be chemically homogeneous since the composition of solids entering and leaving the zone is the same. Final portions of liquid, however, will have an enriched composition. Thus it is possible to obtain an ingot and, under certain conditions, a single crystal, a portion of which will be chemically homogeneous (*19*).

This discussion has been limited to binary systems. The more complicated ternary systems have not been discussed. However, the same general observations still apply. Congruent-melting ternary compounds can be grown as single crystal material from the melt—for example, synthetic phlogopite. The same limitations apply, however. For example, one

can synthesize chalcopyrite by sintering or solid-phase reaction, but quite probably it cannot be grown from the melt since it melts incongruently.

References and Notes

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2. I have drawn freely for my data on the experience of the staff of the Crystal Branch of the U.S. Naval Research Laboratory, including P. H. Egli (head), L. R. Johnson, W. Zimmerman III, O. Imber, C. H. Jackson, and S. Slawson.
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Oceanography, Fisheries, and Atomic Radiation

In writing this report we have had four groups in mind—research administrators, statesmen, scientists, and the public. For those who have responsibility for the support of research, we have attempted to outline the scientific questions that need to be answered as a basis for intelligent policy, the means by which they can be attacked by classical research methods at the outset, and the broader problems of the oceans that can be hopefully attacked by the use of radioactive tracers. For the statesmen who have responsibility for national and international policy, we have attempted to formulate recommendations, based on our present small body of knowledge and our awareness of our larger area of ignorance, concerning the national and international actions and agreements that are necessary for the happy exploitation of the oceans in the new atomic age. For the scientists, we have attempted to summarize what is known about the actual and potential effects of radioactive materials in the oceanic realm and the interest of marine scientists in these substances. For the public, to which we all belong when we are outside our own specialties, we have summarized the levels of calculated risk that must be balanced against the wonderful promise of atomic energy for the welfare of mankind.

How Does the Atomic Energy Program Affect the Oceans?

We have considered three aspects of the atomic energy program that directly involve the oceans and, therefore, the marine sciences: weapons tests over or in the sea, disposal of radioactive wastes from nuclear power plants, and the use of radioactive substances in increasing our understanding of the oceans and of the creatures that live in the sea. These different aspects cannot easily be separated. Weapons tests and the disposal of radioactive wastes present great opportunities for studying the oceans. On the other hand, increased knowledge of the oceans is essential to avoid or minimize the destruction of marine resources in the development of atomic energy.

The continuing development of atomic energy will produce progressively greater amounts of radioisotopes, and with them greater amounts of radioactive waste material. Since the oceans cover 71 percent of the earth, and ultimately receive the drainage from the land, they are the principal reservoir where radioisotopes will finally accumulate. Relatively small quantities are now being added to the surface waters of the ocean as fallout from weapons-testing programs, and in a few places as waste materials.

When nuclear reactors for the production of power are put into large-scale operation, as they certainly will be in the foreseeable future, the oceans will be seriously considered for the disposal of large quantities of wastes. Even if direct and intentional disposal at sea is not practiced, reactors may be built along sea coasts or on rivers near large population centers, and accidental pollution may occur.

The problem of disposal of radioactive wastes is similar in character to, though potentially far greater in scope than, other problems of pollution. An object lesson can be drawn from our experience with the disposal of human and industrial wastes in inland water bodies and coastal waters and with the smog problem that afflicts many of our large cities. During the early stages of the growth of industries and populations in cities, wastes were added to nearby lakes or bays, and to the air, in what seemed at the time to be innocuous quantities. As a matter of fact, the quantities were small enough to be purified by natural processes. In the course of time, however, the quantities increased insidiously so that today many natural waters cannot purify themselves and without expensive treatment are dangerous to human beings.

In almost every case the problem was ignored until it had become formidable in magnitude. Short-range solutions were employed, based on inadequate knowledge, special interest, and what we now know was an unfounded confidence in the capacity of the atmosphere and the waters to absorb noxious substances. As a result, unnecessary damage was done to human beings and their environment. Much of this could have been avoided if an adequate program of scientific investigation had been started sufficiently far

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This article is the text of the summary report of the Committee on the Effects of Atomic Radiation on Oceanography and Fisheries. The report is part of a continuing Study on the Biological Effects of Atomic Radiation conducted by the National Academy of Sciences with the support of the Rockefeller Foundation. The members of the committee are Roger Revelle, Scripps Institution of Oceanography, *chairman*, Howard Boroughs, University of Hawaii; Dayton E. Carritt, Johns Hopkins University; Walter A. Chipman, U.S. Fish and Wildlife Service; Harmond Craig, Scripps Institution of Oceanography; Lauren R. Donaldson and Richard H. Fleming, University of Washington; Richard F. Foster, General Electric Company; Edward D. Goldberg, Scripps Institution of Oceanography; John H. Harley, U.S. Atomic Energy Commission; Bostwick Ketchum, Woods Hole Oceanographic Institution; Louis A. Krumholz, American Museum of Natural History; Charles R. Renn, Johns Hopkins University; M. B. Schaeffer, Scripps Institution of Oceanography; Allyn C. Vine, Woods Hole Oceanographic Institution; Lionel A. Walford, U.S. Fish and Wildlife Service; and Warren S. Wooster, Scripps Institution of Oceanography. Subheads have been inserted in the text. The full report will be published in monograph form by the NAS.

in advance and if scientifically based policies had been followed.

It is imperative that the nature of the wastes associated with the development of atomic energy be evaluated in advance. We know that purification of waters receiving radioisotope waste will proceed only by dilution, by precipitation and settling on the bottoms, and by the decay of radioactivity. Nothing could be done to reverse an undesirable accumulation that might result from ill-considered disposal of this type of waste.

There is no question of trying to keep all of this material out of the sea. It is certain that some of it can be safely added. Tolerability of materials must be determined, and the locations where they should be put must be wisely selected in terms of the quantity and character of the radioactivity. It is not possible today to see clearly the problems of the future; we can only define the studies that must be made to provide a scientific basis for wise evaluation and urge that these studies be begun without delay. The costs of such studies may seem large, but they are actually negligible in terms of the potential benefits. They are also very small when compared with the total present expenditures for the development of atomic energy. We cannot wait to begin these studies until radioisotope pollution becomes serious, for it is irreversible.

Radioactivity in the Sea

Is there naturally occurring radioactivity in the sea? Yes, but one of the remarkable characteristics of the ocean is the extremely low level of the natural radioactivity. Marine animals and plants living more than a few hundred feet beneath the surface are bombarded by much less natural radiation (radioactivity plus cosmic rays) than is received by terrestrial plants and animals.

For example, although radiopotassium accounts for about 90 percent of the activity in the sea, it is present in most igneous rocks at about 100 times the concentration found in the ocean. Uranium, radium, and thorium are 3000 to 1 million times more concentrated in rocks than in the sea. This raises an interesting scientific question concerning the character of genetic change and evolution in many marine creatures. It emphasizes the need for basic biological studies on marine organisms. Because of their experimental difficulty, such studies have been comparatively neglected during the past few decades.

Have weapons tests added measurable amounts of radioactivity to the sea? Yes, though in terms of the total radioactivity of the sea, the amount is negligible. Radioactivity in the waters of the test area is of course very greatly increased at the time of tests, and even after diffusion over thousands of miles, concentrations remain that are readily detectable. Two days after the 1954 tests in the Pacific, the radioactivity of the surface waters near Bikini was observed to be 1 million times greater than the naturally occurring radioactivity. This material was transported and diluted by ocean currents, and 4 months later concentrations 3 times the natural radiation were found 1500 miles from the test area; 13 months later, the contaminated water mass had spread over 1 million square miles. Artificial activity had been reduced to about one-fifth the natural activity, but could be detected 3500 miles from the source.

In what other ways will radioactive materials be added to the oceans? In England radioactive wastes are being piped into the Irish Sea from an atomic installation. In the United States, wastes from laboratories and hospitals are being carried to sea in containers and dumped. At Oak Ridge, some of the fission products are discharged into the Tennessee River system. At Hanford, water from the Columbia River is used for cooling and returned to the river with some induced short-lived radioactivity. Waste products from the uranium fuel processing plants are now being confined, some in containers, others in pits in the ground. When the power reactors and fuel-processing plants reach their expected development, many rivers will have to be used. It will not everywhere be practical to confine the wastes locally. Transporting them to sea in barges or by other means may then be necessary in many cases. Although we may be sure the atomic installations will be carefully engineered and maintained, accidental discharge of waste may occasionally occur. On those occasions, intense radioactivity may reach the sea.

Damage to Marine Life

Has the atomic energy program as yet resulted in serious damage to marine life? Probably no. We know that radioactive radiation is damaging to living things and that marine organisms tend to concentrate many fission-product elements. But there is no evidence that any lasting damage has been done to the animal or plant populations of the sea or of large inland water bodies by the release of radioactive substances.

Certainly in the weapons test area terrestrial forms were killed or injured by the tests. The evidence concerning marine life is not conclusive, but biologists feel certain that deleterious effects occurred in the near vicinity. There is, however, no evidence that populations have been affected after the dilution and transport mentioned above. This is a subject on which intensive studies are essential before a definite answer can be given. We know that "high" levels are lethal, and that "low" levels may have no direct effect, but we cannot give quantitative values for "high" and "low" except in a few cases. Low levels, which produce no measurable effect in the organism itself, may produce genetic effects and thus influence the marine populations in the future, but there is no conclusive evidence that this will be undesirable.

Do living things take up radioactive materials into their bodies? Yes. Radioactive materials added to the sea can remain in solution, precipitate and settle on the bottom, or be taken up by the plants and animals that live in the water. The plants of the sea are mainly microscopic in size, but they can concentrate many thousandfold those elements that are necessary to them. Radioactive substances are also absorbed on the body surfaces of living things. Small plants and animals serve as food for the larger forms, and the radioactive materials are passed on from one to another. The amount of each element accumulated in each form depends upon the rate at which it is taken up, either directly or as food, and the rate it is excreted. Some of the radioactive materials remain in the body for relatively long periods of time and may accumulate to a considerable degree. Others may be lost rapidly and very little will accumulate.

This statement is a great oversimplification. Different plants and animals require and accumulate different elements. Shell fish, for example, concentrate calcium and strontium in their calcareous shells; fish concentrate zinc. It will be necessary to know among other things both the composition of the waste, and the populations in the area, before any particular disposal operation can be evaluated.

Are all the radioactive elements equally harmful? No. Those elements that living organisms naturally accumulate and that have long radioactive half-lives are more harmful than others. Radioactive strontium, and to a lesser extent, cesium and its daughter barium, cerium, praesodymium, and promethium represent particular hazards to human beings from ocean disposal.

Radioactive Waste

How much radioactive waste will be produced by nuclear power reactors in the future? The answer to this depends upon how optimistic one is concerning the development of nuclear power. One estimate assumes that within about 50 years nuclear fission will be producing

about half as much power annually as the peoples of the world are using today from all sources.

Accumulations year after year will eventually result in a constant quantity of radioactivity, such that the rate of radioactive decay will balance the rate of production of fission products to give what has been called the steady state. This should be approached within a few decades after full production is reached. The waste radioisotopes at this point would equal between 1 and 2 times the total natural radioactivity in the world oceans. This is roughly 1000 times the amount produced so far in weapons tests.

What means are being considered for disposing of radioactive wastes? The methods being considered fall into two categories, isolation and dispersal. It is probable that a judicious combination of the two methods for different types of wastes or for different countries will be essential. Chemical treatment of the wastes to isolate usable fractions, or those, like strontium and cesium, that decay most slowly, offers promise in simplifying the problem. For isolation, permanent storage in tanks or introduction into geologic structures such as salt domes are being studied by other committees. The only place on earth where dispersal can be considered practical is in the ocean. Because it is large and fluid, the ocean could provide immense dilution. Because of its depth, and the stratification of water masses with differing densities, various degrees of isolation may be possible. It is a prime purpose of this report to emphasize the need for investigation as to whether this possible isolation is adequate.

Will it be safe to introduce very large quantities of radioactive wastes from atomic power indiscriminately into the sea? The answer is certainly no, but the strongest negative must be given for coastal waters and for the upper water layers everywhere that are the home of commercially important fishes. These surface waters interconnect and are in continuous motion. Anything added in one spot will, in the course of a few decades at most, be carried to all parts of the world. There is no place in the sea where very large amounts of radioactive materials can be introduced into the surface waters without the probability of their eventually appearing in another region where human activities might be endangered.

It should not be forgotten that the coastal waters enter the harbors and estuaries and would carry any waste materials there with them; and that many of the major fishery resources of the world are concentrated over banks and near coasts, and would become contaminated.

We must also remember that all plants and animals in the sea, from the smallest bacteria to the largest whale, play a part in concentrating, transporting, and dispersing radioactive and other dissolved and suspended materials.

Does this mean that large quantities of radioactive wastes should never be dumped in the sea? No, not necessarily, but it does mean that the length of life of the radioactive material, its role in biological processes, and the mixing rate of the ocean should be carefully studied before large quantities of wastes are introduced into the sea. Unfortunately, although we know the decay time of most radioactive substances, we know very little about the exchange processes in organisms and in the water. We do know that even the bottom waters of the deep ocean basins slowly exchange with those of the surface, but the rate of this exchange is uncertain.

From what is known, where would be the safest place to dump radioactive wastes in the sea? At the present time it is only possible to give rough engineering estimates, based on order-of-magnitude calculations.

Remembering the importance both of isolation (to allow time for radioactive decay) and dispersal (to reduce the amount of radioactivity per unit volume) the problem is to find places in the ocean where the rate of transfer of radioactive materials to the surface waters would be slow, or where great dilution would occur before radioactive materials came in contact with marine food products or human beings, and preferably where both conditions would prevail.

There are some places where a contaminant could be isolated for long periods. For example, it is estimated that in the deepest parts of the Black Sea the "flushing time" is about 2500 years. This is the time required for most of the deep water to move near to the surface and be replaced with new water mixing downward. In this respect the Black Sea is unique. Elsewhere the "age" of the deep water indicates that exchange with the near surface waters goes on less slowly. Thus in the deeps of the Atlantic and Caribbean the time required for replacement of the water with new water from near the surface is probably only a few hundred years. Some oceanographers believe that the Atlantic deep water sank from the surface in high northern latitudes about 150 years ago.

We are fairly certain that substantial amounts of long-lived radioactive materials, dumped on the bottom in the deep sea, would remain isolated for more than 100 years and that during this period they would become diluted by mixing through an enormous volume of deep water. We do not understand the nature of the physical and biological exchange processes between the deep and surface waters well enough to be able to say whether in the steady state, after decades of nuclear power production, deep-sea disposal would give adequate protection of the commercial fisheries from long-lived fission products such as strontium. Large quantities of short-lived fission products could certainly be disposed of safely in this way.

Use of Radioactive Materials to Study the Ocean and Fisheries

Can radioactive materials be used to learn about the oceans and to increase the harvest from the sea? Yes. For example, an understanding of the flow of material through food chains is essential to the effective use and conservation of the food resources of the sea. The natural elements used by the marine plants and their transfer to the commercially valuable fish and shellfish can be studied on a large scale, using radioactive isotopes. As these readily detectable substances are traced through the various steps of the food chain—plants, animal plankton, small fish, large fish—the efficiencies and interrelationship of the various levels should become much better known. This knowledge is of fundamental importance for the evaluation of the potential of the living resources of the sea as a source of food and other marine products, and as a basis for their full utilization and conservation.

Radioactive materials, both natural and man-made, can also be used in the study of oceanic mixing processes and circulation. These processes serve to supply marine plants with the fertilizers they need from deeper waters, as well as to dilute and disperse radioactive wastes dumped in the sea. At present we cannot measure, but can only estimate, the mixing rates. The ability to trace radioactive materials, even though present in great dilution, will permit us to obtain quantitative information. Improved knowledge of the mixing processes and of currents will help man to locate and evaluate unexploited resources of fish and other food organisms.

For example, 13 months after radioactive materials were introduced into the sea by fallout from weapons tests in the Marshall Islands, a research vessel traced their distribution in the Western Pacific. The extent to which radioactivity was taken up by plankton and fish was measured, as well as the extent to which activity was mixed downward and transported westward in the western limb of the great North Pacific eddy. These measurements showed the average speed at which materials were carried away

from the test area, giving convincing proof of the transport and mixing of material over a vast region.

Large amounts of radioactive tracers ranging in magnitude from curies to megacuries can be used at sea in studying oceanographic problems, including the problems of fisheries, and thus laying the groundwork for increasing our harvest from the ocean. Smaller amounts are needed in the laboratory. We are here concerned not with the general problems of physiology and biochemistry but with specific ecological studies, including investigations of the efficiency of transfer of energy along the food chain, rates of filtration, concentration of elements and compounds in various tissues, the rates of accumulation and excretion of elements and compounds, the passage of substances across biological membranes, the concentration and role of biotic and antibiotic substances in the sea, the dynamics of marine populations, including the mass of living material in a given volume of water, the flux of organic substances from one organism to the other and between the organism and the sea water, and the interrelationships between animal and plant communities. In both field and laboratory experiments, fission products are useful, but some problems require the use of artificially radioactive substances produced by other means. An outstanding example is the use of carbon-14 to study the efficiency of various steps in the food chain. Large quantities of this material are needed for field studies in restricted water bodies. Although the cost would be high, the value of the results would more than justify the expenditure.

Conclusions and Recommendations

1) Tests of atomic weapons can be carried out over or in the sea in selected localities without serious loss to fisheries if the planning and execution of the tests is based on adequate knowledge of the biological regime. The same thing is true of experimental introduction of fission products into the sea for scientific and engineering purposes.

2) Within the foreseeable future, the problem of disposal of atomic wastes from nuclear fission power plants will greatly overshadow the present problems posed by the dispersal of radioactive materials from weapons tests. It may be conveninent and perhaps necessary to dispose of some of these industrial wastes in the oceans. Sufficient knowledge is not now available to predict the effects of such disposal on man's use of other resources of the sea.

3) We are confident that the necessary knowledge can be obtained through an adequate and long-range program of research on the physics, chemistry, and geology of the sea and on the biology of marine organisms. Such a program would involve both field and laboratory experiments with radioactive material as well as the use of other techniques for oceanographic research. Although some research is already underway, the level of effort is too low. Far more important, much of the present research is too short-range in character, directed toward *ad hoc* solutions of immediate engineering problems, and as a result produces limited knowledge rather than the broad understanding upon which lasting solutions can be based.

4) We recommend that in future weapons tests there should be a serious effort to obtain the maximum of purely scientific information about the ocean, the atmosphere, and marine organisms. This requires, in our opinion, the following steps: (i) in the planning stage committees of disinterested scientists should be consulted and their recommendations followed, (ii) funds should be made available for scientific studies unrelated to the character of the weapons themselves, and (iii) the recommended scientific program should be supported and carried out independently of the military program rather than on a "not to interfere" basis.

5) Ignorance and emotionalism characterize much of the discussion of the effects of large amounts of radioactivity on the oceans and the fisheries. Our present knowledge should be sufficient to dispel much of the overconfidence on the one hand and the fear on the other that have characterized discussion both within the Government and among the general public. In our opinion, benefits would result from a considerable relaxation of secrecy in a serious attempt to spread knowledge and understanding throughout the population.

6) Sea disposal of radioactive waste materials, if carried out in a limited, experimental, controlled fashion, can provide some of the information required to evaluate the possibilities of, and limitations on, this method of disposal. Very careful regulation and evaluation of such operations will, however, be required. We, therefore, recommend that a national agency, with adequate authority, financial support, and technical staff, regulate and maintain records of such disposal, and that continuing scientific and engineering studies be made of the resulting effects in the sea.

7) We recommend that a National Academy of Sciences–National Research Council committee on atomic radiation in relation to oceanography and fisheries be established on a continuing basis to collect and evaluate information and to plan and coordinate scientific research.

8) Studies of the ocean and the atmosphere are more costly in time than in money and time is already late to begin certain important studies. The problems involved cannot be attacked quickly or even in many cases, directly. The pollution problems of the past and present, though serious, are not irremediable. The atomic waste problem, if allowed to get out of hand, might result in a profound, irrecoverable loss. We, therefore, plead with all urgency for immediate intensification and redirection of scientific effort on a world-wide basis toward building the structure of understanding that will be necessary in the future. This structure cannot be completed in a few years; decades of effort will be necessary and mankind will be fortunate if the required knowledge is available at the time when the practical engineering problems have to be faced.

9) The world-girdling oceans cannot be separated into isolated parts. What happens at any one point in the sea ultimately affects the waters everywhere. Moreover, the oceans are international. No man and no nation can claim the exclusive ownership of the resources of the sea. The problem of the disposal of radioactive wastes, with its potential hazard to human use of marine resources, is thus an international one. In certain countries with small land areas and large populations, marine disposal of fission products may be essential to the economic development of atomic energy. We, therefore, recommend: (i) that cognizant international agencies formulate as soon as possible conventions for the safe disposal of atomic wastes at sea, based on existing scientific knowledge; and (ii) that the nations be urged to collaborate in studies of the oceans and their contained organisms, with the objective of developing comparatively safe means of oceanic disposal of the very large quantities of radioactive wastes that may be expected in the future.

10) Because of the increasing radioactive contamination of the sea and the atmosphere, many of the necessary experiments will not be possible after another 10 or 20 years. The recommended international scientific effort should be developed on an urgent basis.

11) The broader problems concerned with full utilization of the food and other resources of the sea for the benefit of mankind also require intensive international collaboration in the scientific use of radioactive material.

Disposal and Dispersal of Radioactive Wastes

Experience in handling the waste-disposal problems to date is mostly limited to conditions as they exist in the areas of the national atomic energy establishments. The determination of hazards from the disposal of wastes in these areas, most of which are in remote and somewhat isolated regions, involving relatively short periods of time, has to date revealed no deleterious effect on the public or its environment.

This does not provide, however, a completely adequate basis for projecting the magnitude of the hazard into the vastly expanded realm of industrial atomic power production. Not only does the problem itself take on new significance with the projected amount of wastes, but environmental factors which may lie dormant under conditions existing in the remote areas take on full-blown importance when viewed under the more stringent requirements for highly populated areas.

Many such problems immediately come to the surface as a result of consideration of the long-term legal and insurance aspects. These problems reflect first of all a need for deeper understanding of the basic issues and for more refined measurements, and not merely for greater but still unknown factors of safety. Long-term responsibilities—moral, legal, and financial—stemming from the ownership of atomic wastes simply come into sharp focus when it is emphasized that the radioactive life of the wastes would probably exceed by several centuries the official life of the organization itself. Legal and insurance requirements, therefore, will undoubtedly have a great deal to do with the shaping of rigid administrative policies with respect to these long-range aspects of the atomic-waste disposal problem. It may be difficult to maintain an adequate balance between objectives which primarily must emphasize the legal requirements and those which in the broad biological sense must establish the foundations for a truly preventive approach to this problem.

This article, with slight shortening of the subheads, is the text of the summary report of the Committee on Disposal and Dispersal of Radioactive Wastes. The report is part of the Study on the Biological Effects of Atomic Radiation conducted by the National Academy of Sciences with the support of the Rockefeller Foundation. The full report will be published in monograph form by the NAS. Members of the committee were Abel Wolman, Johns Hopkins University, *chairman*; F. L. Culler, Oak Ridge National Laboratory; Arthur E. Gorman, U.S. Atomic Energy Commission; L. P. Hatch, Brookhaven National Laboratory; H. H. Hess, Princeton University; Clarence W. Klassen, Illinois State Department of Public Health; Sidney Krasik, Westinghouse Atomic Power Division; Joseph A. Lieberman, U.S. Atomic Energy Commission; H. M. Parker, General Electric Company; W. A. Patrick, Johns Hopkins University; Sheppard T. Powell, consulting engineer, Baltimore, Md.; Leslie Silverman, Harvard University; Philip Sporn, American Gas and Electric Company; Conrad P. Straub, Oak Ridge National Laboratory; Charles V. Theis, U.S. Geological Survey; and Forrest Western, U.S. Atomic Energy Commission.

Present Status of Problem

The following listing summarizes the conclusions regarding the status of waste dispersal and disposal operations.

1) The safe handling and ultimate disposal of radioactive wastes is an important technical, economic, and administrative aspect of the nuclear energy industry. Waste operations must be thoroughly integrated with all other phases of nuclear energy operation.

2) From a technologic standpoint, the highly radioactive wastes resulting from the processing of reactor fuels constitute the bulk of the problem. To date essentially none of those wastes has been disposed of—that is, returned to the environment. Tank storage is presently utilized as an interim answer to this problem.

3) Wastes resulting from normal reactor operations are an important consideration, but technically represent a problem for which solutions are generally available.

4) Research and development have indicated possible feasible systems for ultimate controlled disposal of highly radioactive wastes, but considerably more work is required to bring these systems to the point of economic operating reality.

5) Major technical and economic considerations underlying the waste problem are (i) characteristics of nuclear fuels and chemical (or other) processing associated with them; (ii) separation of specific isotopes from the wastes and use of these materials to economic advantages; (iii) the proper selection of the site for nuclear facilities—especially reactor and fuel-processing plants; (iv) the detailed quantitative evaluation of the environment in order to assess its capacity to receive radioactive materials without creating deleterious effects on the environment; [and] (v) systems for the physical handling and transportation of highly radioactive materials.

6) Major policy and administrative considerations relevant to the regulation of the waste problem are (i) the establishment, perhaps through private enterprise, of suitable waste disposal services; (ii) the regulation and control of waste-disposal practices through existing and traditional state, interstate, and local channels where feasible; [and] (iii) continuation and strengthening of established practices in relations with the public and its agencies.

Growth of Nuclear Industry

Based on the best estimates available (which vary over rather wide ranges) and, to a substantial extent on technical judgment, the indications are that the principal source of fission products from nuclear reactors in the next decade will arise from the generation of electricity at nuclear-powered central stations. On the basis of present developments, the second most important source probably will be reactors for naval service. Compared with these, other sources are comparatively small and amount to substantially less than the uncertainty in the estimates of the principal uses.

By 1965 the average rate of reactor heat release is estimated to be about 11 million kilowatts. Naval service will account probably for 20 percent of this output in 1965. This rate of heat release will result in the production of somewhat over 10 kilograms of fission products per day in 1965.

In addition, the presence of radioactive wastes in quantity will have a profound effect on certain nonnuclear industries which may be damaged by air or water contaminated with radioactive wastes. Numerous wet-processing industries are likely to be detrimentally affected by radioactive wastes even in trace concentrations. Among this vulnerable group are those requiring water of the highest purity, such as for the manufacture of photographic film. Other industries which should be alerted to the problem are pharmaceutical manufacturers and food-processing companies. It is not possible, at this time, to enumerate with assurance the industrial processes which can be

completely eliminated as subjects of this potential hazard, without the assembly of extensive research and statistical data applicable to specific operations.

Fuel Processing and Types of Reactors

Neither the type of fuel nor the length of irradiation time greatly influences the accumulated total radioactivity of fission products. After approximately 3 years' decay, the residual radioactivity is essentially the same for various irradiation times, assuming constant heat generation during the irradiation period.

Essentially all of the radioactive material from fuel-separations processes must be kept from the environs to maintain human exposures within maximum permissible limits. An important problem which possibly limits storage volume is the rate of heat removal from the containers. After solvent extraction wastes are concentrated by supplied heat to about 2000 gallons per ton of irradiated uranium, the heat of radioactive decay will continue the concentration to 100 to 500 gallons per ton. Practical heat removal mechanisms may require that more concentrated waste produced by other separations processes be diluted to the same volume range. More concentrated fluid wastes also need stronger, less economical containers. The volumes of stored waste accumulated by 1980 are estimated at 20×10^7 gallons, by 1990 at 60×10^7 gallons and by 2000 at 240×10^7 gallons.

The future possibility of high burn-up of reactor fuels might ultimately result in a situation where processing may be unwarranted. This would not change accumulation of fission products, but would have a profound effect on waste storage and disposal considerations. Similarly, the development of nonaqueous chemical processing methods would be important in modifying the waste-management problem.

Isotopes Problems

The technical and administrative problems associated with the transport, use, and disposal of radioactive materials in medicine, biology, and industry will undoubtedly grow in complexity and quantity as the demand for the use of these radioactive materials increases. The expanding demand is already apparent in the rapidly increasing number of individual isotope users as evidenced by the expansion of the isotope-distribution program. The program for the distribution of reactor-produced radioisotopes is nearing 1 decade, having been initiated on 2 August 1946. During this period, more than 100,000 shipments of radioisotopes have been made from AEC facilities to some 3200 institutions throughout the United States. These materials are being applied in science, agriculture, medicine, and industry. The Oak Ridge National Laboratory, the principal radioisotope-production facility in the United States, has shipped approximately 130,000 curies to date.

All indices of radioisotope utilization reveal continued rapid growth. A look at the last 3 years of the program shows a growth in the number of using institutions from 1400 to 3200. This is an increase of approximately 125 percent. There has been a 100-percent increase in annual numbers of shipments made since 1 January 1953. The principal growth during the period has been in the industrial use of radioisotopes.

However, of even greater significance in connection with environmental and hazard-control problems is the ever-increasing desire for larger and larger individual sources of radioactivity. Requirements for intense radiation sources are obviously at their earliest stages. Such uses as food and pharmaceutical sterilization, promotion of chemical reaction, and other yet unknown applications will undoubtedly result in a much more extensive use of mobile and more widespread sources of intense radiation.

Increased use, especially of highly active materials, and the increase in the production of by-product materials at widely scattered geographic locations will result in ever-increasing new technical and especially administrative problems in both the transport of the material and the disposal of the wastes, in order to protect the environment against normal and potential emergency hazards.

Compliance with existing transportation regulations presents few significant problems in the shipment of by-product material even though certain specific limitations exist. However, consideration should be given to a complete critical review of existing ICC, Civil Air, Coast Guard, and Postal regulations to bring them in line with current requirements and radiation safety knowledge.

The radiological health and safety record in the nationwide use of radioisotopes is excellent. Incidents which have come to the attention of the Atomic Energy Commission involving significant overexposure of personnel are exceedingly small: fewer than ten. In large measure, this may be attributed to active educational efforts in radiological protection through a field advisory service to isotope users and through effective and practical licensing practices.

At present activity levels of use of radioisotopes and with the wide dispersal of users, substantial environmental health problems do not exist due to waste disposal or other practices resulting in the introduction of radioisotopes into the environment.

The following listing summarizes [our] conclusions [concerning items that require further study]: (i) geophysical and geochemical aspects of ultimate disposal of highly radioactive wastes; (ii) site selection for various nuclear facilities, particularly chemical processing plants and their location with respect to suitable waste disposal areas; (iii) transportation of highly radioactive materials; (iv) relationship of introduction and development of nuclear facilities to basic public health, social, and economic situations extant or resulting from such development.

Accidental Hazards

The following conclusions in respect to the consequences of accidents involving radioactive materials appear warranted.

1) The problems of waste disposal could be international in character and must be solved technically so that the total environment is maintained at a low level of radioactivity in order that accidents that are bound to occur will not be disastrous.

2) The type of accident that could result in a catastrophic spread of radioactive materials is the complete vaporization of the core of a reactor and its release to the surroundings. The probability of a catastrophic accident with a properly designed nuclear reactor is extremely small.

3) Reactor waste processing plants or storage facilities offer a greater hazard on a long-term basis than any single reactor.

4) Accidents in handling, transport, and chemical separation of radioactive materials, while locally severe, should not affect a wide public area and, in all cases, the contaminated areas can be cleaned up.

5) The probability of accidents in handling radioactive isotopes and low-level radioactive materials is similar to that in handling other types of lethal substances.

6) Use of nuclear reactors to drive ships appears feasible from a consideration of the consequences of possible accidents provided that uranium-233 and plutonium are kept to a minimum. The technology of the use of nuclear reactors to drive locomotives and commercial airplanes has not developed to the point where the committee can form a judgment as to the consequences of possible accidents.

7) Development of improved methods to limit the volumes of wastes produced in nuclear power reactors is justified from the viewpoint of the hazards due to possible accidents.

8) Continuous and vigorous appraisal of reactor and fuel-processing plants design and operation and waste storage will

be required in all nations using atomic energy in order to keep the radioactivity level of the world environment at tolerable levels.

9) Improved safety devices for control of transients in nuclear reactors should continue to be vigorously developed.

10) Further tests are required of reactors to evaluate their ability safely to withstand power excursions which may occur as a result of unusual operating circumstances.

11) Until such time as advances in the technology of reactors lessen potential hazards substantially, sealed buildings properly designed, constructed, and tested should be required for all nuclear reactors to be built in or near populated areas.

12) All operations involving radioactive materials in sufficient amounts to create possible health hazards should be supervised by trained and responsible people.

Fallout Considerations

It is apparent that as of the present time the dispersal of radioactive material resulting from weapons testing has not been an environmental contaminant of substantial public health significance. However, because of various unknown factors regarding the distribution and ultimate fate of this material, plus the potentials of possible wider spread and more frequent weapons testing, it is also apparent that the subject in all of its aspects merits meticulous and continuing attention. The problem of fallout is one of international significance and should be studied and evaluated on that basis, perhaps looking forward to international cooperation in control.

Louis C. Karpinski, Historian of Mathematics

Although he was best known and probably will be longest remembered as a historian of mathematics, Louis Charles Karpinski was remarkable for his breadth of interests and his vigorous pursuit of them. These included cartography, American history, bibliography and book collecting, chess, and public utility rates.

After graduating from Cornell University in 1901 where he was the ranking player on its championship chess team, he journeyed to the University of Strassbourg in France. There he completed in 1903 a doctorate in mathematics with a thesis in number theory. Upon his return to this country, he taught for a year at Oswego State Normal School, before being appointed to an instructorship at the University of Michigan where he remained, except for leaves, until his retirement in 1948.

His activities while on leaves from the university were typical of his interests and greatly influenced them. The first of these was a year (1909–1910) spent as a fellow at Teachers College, Columbia University. There, with David Eugene Smith, he developed his interest in the history and pedagogy of mathematics, the fields wherein lie his greatest contributions, both in research and in teaching. Out of this period came his first of more than ten articles in *Science, The International Commission* [on the Teaching of Mathematics], and his first book, *The Hindu-Arabic Numerals,* (1911) written jointly with David Eugene Smith. This work is still the most complete and accurate study of this topic available.

His *History of Arithmetic* (1925) and monumental *Bibliography of Mathematical Works Printed in America Through 1850* (1940) show the continuity and vigor of his interest in the history of elementary mathematics and in bibliography. Also of a bibliographic nature are his two books on the early maps of the Great Lakes and Michigan. These volumes published by the Michigan Historical Commission represent an even broader interest in maps and historical source materials.

It was typical of him that he not only enjoyed these interests but made them serve him both financially and in the pursuit of his research. He helped finance one trip abroad by the sale of his map collection to Yale University and another by photographing manuscripts related to America in libraries and archives in France, Spain, and Portugal. Shopping in bookstores on his trips abroad and avidly scanning catalogs from dealers all over the world were the means of constructing what is probably the most lasting monument to Professor Karpinski, the outstanding collection of source materials in the history of science that he built up in the University of Michigan Library.

The internationalism of his interests (he was proud of his father's Polish birth) is further attested by the range of foreign journals in which his more than 100 publications appeared (for instance, *Biblioteca Mathematica, Isis, Archeion*), his publications of studies of Spanish, Italian, Provencal, English, and Arabic algebraists and arithmeticians, and the fact of which he was most proud—namely, that he was elected an effective member (No. 14) of the Comité Internationale d'Histoire des Sciences at the time of its establishment. He also served a term as chairman of Section L of the AAAS, and later (1941) was elected president of the History of Science Society.

He was frequently involved in controversies, because he was sensitive to what he thought to be wrongs to himself or to society and responded fearlessly and vigorously when a wrong was perceived. It was in this spirit that he attacked utility rates and studied this problem to the extent that he was once listed as an "expert" on them. His colleagues and friends often secretly admired his forcefulness and fearlessness in rushing to an attack where others awaited more data or a better opportunity. His students recall him affectionately as one whose friendliness as a counselor belied his occasional classroom "bark" and as one who was always ready to help, even beyond the regular duty of an instructor, with suggestions and materials from his own resources and with references from his astonishing reserve of information about the literature of his fields.

He died in his sleep early in the morning of 25 January 1956 at his home in Winter Haven, Florida, from which since his retirement he had continued as a book dealer to exercise his bibliophilistic urge.

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News of Science

Nuclear Notes

Thomas E. Murray, commissioner, U.S. Atomic Energy Commission, submitted a statement on the U.S. reactor program to the Joint Committee on Atomic Energy on 18 June that contained the following comments:

"The increasing threat of world destruction compels me to urge again the acceleration of effort on peacetime power reactors.

"The prospect of getting industrial atomic power in the near future is very gloomy. The Government has prematurely abdicated to private industry the primary responsibility for building large power reactors.

"Important reactor types have been "staked out" by individual companies or groups. Yet there is no firm assurance that these and other power reactors will be built in the near future.

"Repeating a recommendation made last February, I again urge the Government to assume the primary responsibility for large reactor construction.

"While continuing to support the Power Demonstration Program, I recommend that the Government construct several large power reactors. These reactors should be located at AEC production facilities thus eliminating the issue of public versus private power.

"A program of large reactor construction would help private industry. It would also enable us to keep our repeated and widely publicized promises to make available the benefit of atomic energy to mankind at an early date.

"I strongly recommend that Congress enact legislation similar to that proposed by Senator Albert Gore and Congressman Chet Holifield. This legislation should provide for a program of large power reactor construction generally along the lines I have proposed and at the locations I have suggested."

* * *

The current issue of *Nucleonics* contains the complete text of the recent speech in Britain by Igor V. Kurchatov on Soviet progress in controlled nuclear fusion. The magazine also presents comments from officials in the atomic energy field here and abroad pertaining to Western policies on the release of similar information.

Sen. Clinton P. Anderson (D-N.M.), chairman of the Joint Committee on Atomic Energy, stated that there is a need for more unclassified discussion:

"Too often the best ideas in basic long-range theory come from people who are entering the field for the first time with brilliant minds, a fresh perspective, and untrammeled by security restrictions—people who are able to think and talk freely. To me, classification of this program merely proves that we lose our main strength in our traditional freedom to search for new ideas when we try to classify basic scientific work such as controlled fusion."

However, Lewis L. Straus, chairman of the Atomic Energy Commission, said he could not predict whether or not the AEC plans any further issuance of unclassified information on the subject: "You will understand that I cannot forecast future actions by the Commission, being one of five members who reach decisions as a group." Sir Edwin Plowden, chairman of the British Atomic Energy Authority, declared: "It is not the present intention of the UK Atomic Energy Authority to make any further release of information on this subject."

D. J. Hughes of the Brookhaven National Laboratory made the following statement:

"In my opinion, the controlled thermonuclear field should be opened up completely in this country, and at once, so that progress will be accelerated. "Kurchatov's speech is a typical high-level technical talk, honest and straightforward, and not an attempt to convey the impression of releasing information without really doing so. It seems very important to me to note that the thermonuclear work represents the first time that the Russians have released information ahead of us."

J. G. Beckerly of the Schlumberger Well Surveying Corp., Houston, Tex., and former director of classification of the AEC, urged: "It is to be hoped that the Kurchatov lecture will stimulate public and private debate on the wisdom of continuing secrecy on controlled thermonuclear reactors. Scientists should realize that the AEC's information policy on fusion power represents a radical departure from the traditional openness of nonweapons basic research in peacetime."

* * *

Last month some 350 scientists participated in a 5-day meeting in Gatlinburg, Tenn. They met for the Sherwood Conference, as it was called, in a theatre, with guards at the door. None would discuss the meeting for publication, but reporters learned that the group was engaged in a nuclear fusion research program.

* * *

For the first time since Canada's atomic project opened in 1947, photographers were permitted to take pictures without restriction. The relaxation of security took place during a visit to the plant by President Sukarno of Indonesia. The step was in line with the policy of Atomic Energy of Canada, Ltd., to end the mistaken belief that work at the project is classified. Virtually all information relating to peacetime uses of atomic energy now is off the secret list.

* * *

Great Britain and the United States have at last come to a limited agreement on the exchange of nuclear information. The pact ends a 10-year ban imposed by Congress on the sharing abroad of certain types of nuclear information. British defense and scientific circles are pleased about the exchange arrangement because it is expected to save millions of pounds and years of effort by eliminating research duplication.

However, the *Manchester Guardian* commented in its 15 June issue that the new pact was a "small agreement" that should be "welcomed but not enthusiastically." The "biggest overlap of efforts" in the atomic field was still in nuclear weapons, The *Guardian* said. It pointed out that no exchange of information in this field was provided for in the agreement.

"In money terms it would not be a bad guess to say that more than £100 million [$280 million] are spent each year in this country on making nuclear bombs." The *Guardian* cited that "waste" of resources involved in making these weapons and said:

"If there were no means of avoiding this waste we should have to shoulder it and be cheerful. But the Americans are doing exactly the same thing."

The *Guardian* called for "an agreement that will allow both countries to shed some of this load."

* * *

The British Medical Research Council's report on nuclear hazards was released recently, and the *New Statesman and Nation* had this to say:

"In discreet and balanced terms the report . . . is the writing on the wall. . . . Statesmen will ignore it at our peril. Sir Anthony Eden can use it in either of two ways or both. He can say 'The scientists have reassured me I can go ahead with the H-bomb tests,' or he can say 'They have warned me we must hurry to reach an agreement to abandon or restrict atom tests.'

"The report shows that the amount of radiation in radioactive materials so far released by the H-bomb tests is not sufficiently serious to affect the human race. But it also shows that persistent tests will raise to a danger point the amount of radio strontium stored in the world's atmosphere."

When Anthony Eden then announced that nuclear tests would be held in the Central Pacific early next year, two British publications commented as follows:

Times Weekly Review: "Three powers —Britain, the United States, and the Soviet Union—have the weapon. All three shrink from the thought that it should ever be used. It is surely time to agree that nothing is to be gained by demonstrating that one or other is momentarily leading in the race of destructive invention. It should surely be possible at least to agree upon some limitation of the frequency of these tests. Whether rationing of explosions should be made part of general negotiations on disarmament or be made a separate urgent topic is a matter on which different opinions may be held. The danger is that rationing will always be supported by the power that believes itself to be temporarily in the lead and opposed by those which hope by the next experiments to catch up. But this line of thought implies a clinging to the belief that it is possible to win a thermonuclear war—and here is the ultimate fallacy."

The Economist: "Sir Anthony seemed to reason that Britain is justified in setting off these explosions because the Americans have had their tests at Bikini and the Russians theirs in Siberia. This is precisely the argument most likely to be used by the other countries which may soon be joining the queue of H-bomb testers. The British decision to carry on with next year's test would be more easily justified if it were accompanied by an attempt to arrange some kind of international rationing of explosions. Unfortunately, Sir Anthony, while welcoming the idea of a rationing agreement, has not yet tried to bring one into being. Britain's aim seems to be to get its own series of tests over and done with before any rationing system enters into force. This sets a bad example to other countries and may well make it more difficult to reach an agreement."

* * *

A report from the Polish Embassy in Washington, D.C., announces that Poland has begun construction near Warsaw of what is to be its principal atomic research center. According to Prof. Andrzej Soltan, head of the Nuclear Research Institute of the Polish Academy of Sciences, the center's reactor is expected to be in operation towards the close of next year.

The report went on to say that work is also being speeded on the building of additional laboratory and lecture facilities for the Nuclear Research Institute at Krakow. The center will be equipped with a cyclotron from the U.S.S.R. Krakow scientists were among the first in Poland to study nuclear phenomena. Some years ago they built a small cyclotron, the first in the country, and have constructed a generator of the Van de Graaff type. They have also done work in magnetic nuclear resonance, neutron diffusion, and the spectroscopy of gamma and beta rays. The Krakow center, headed by Prof. Henryk Niewodniczanski, will work closely with the main Warsaw atomic research establishment.

Next fall Polish physicists will be hosts to an international conference on the theory and problems of elementary particles. The meeting is being organized at the initiative of Prof. Leopold Infeld, theoretical physicist and former coworker of Albert Einstein, as part of a broad program to expand cooperation between Polish scientists and scientists abroad.

The final paragraph of the embassy release said that Prof. Marian Danysz, a Polish expert on cosmic radiation, has indicated that as a result of the establishment in Moscow last March of the Joint Institute of Nuclear Research, Polish physicists would have new opportunities for the investigation of elementary particles and other atomic problems. The institute, of which Prof. Danysz is a deputy director, is an international research organization set up jointly by the U.S.S.R., the People's Republic of China, the East European People's Democracies, the Korean People's Democratic Republic, and the Mongolian People's Republic.

* * *

Masutaro Shoriki, the State Minister of Japan who is also chairman of Japan's Atomic Energy Commission, has announced he favors importing British rather than American nuclear power plants. He said he had made the decision after conversations with Sir Christopher Hinton of the British Atomic Energy Authority, and Marvin Fox, chairman of a survey group from the Brookhaven National Laboratory that has been in Japan completing an Asian survey.

An article in the *New York Times*, datelined Tokyo, said that the Brookhaven group, which has just left Japan after visiting 14 countries in ten weeks, found Japan far ahead in potentialties for nuclear development, although India holds the lead at present in actual construction of research devices.

Fox reported that Asians generally are making a mistake in expecting atomic energy to cure virtually all their economic ills in quick time. He indicated that since power generated by atomic energy will not be an economic proposition for some time, it would be better if Asians went ahead with conventional hydroelectric projects at this stage. "Asian countries are wasting vast potentialities for hydroelectric power," he said. Partly at his suggestion, the Japanese Atomic Energy Commission is planning to send survey teams to Britain, the United States, and Canada.

The survey team said that the Japanese have made the most progress in Asia in plans and technique for the adaptation of atomic power. However, the Indians already have a small research reactor of their own manufacture in operation and are building a much more advanced $15 million model, to which Canada is contributing about half the cost.

The Americans found Pakistan considerably disgruntled with the progress India is likely to make with Canada's assistance in the atomic field, compared with what Pakistan might do with a $350,000 grant from the United States toward a small experimental reactor.

The Brookhaven group was making the survey to determine the best means of utilizing the Asian Nuclear Center that the United States is sponsoring in Manila. A recent Associated Press report about the Manila center said that, although Philippine leaders generally are enthusiastic about the proposed center, some have privately expressed misgivings about the reaction to the project in other Asian countries.

Some sources feel that the Washington decision was based on purely political reasons and not on realistic grounds. They admit, somewhat reluctantly, that such countries as Japan, India, and Ceylon are more advanced in nuclear knowledge than the Philippines and should have been the location for Asia's first atomic plant.

A Philippine congressional faction, moving for closer ties with Asian neighbors, viewed the American decision to set up the atomic plant in Manila as another step in harnessing the Philippines permanently to the United States. The group felt that the center should have been established elsewhere in Asia, despite the temporary loss of prestige for the Philippines, to show other Asians that the United States is not prejudiced

and would not forsake the technical advances in other countries for politics.

* * *

At the recent meeting of the American Medical Association, L. Phillips Frohman, chairman of the section of general practice, warned that the atomic age in medicine is approaching at so rapid a pace that most physicians are not prepared for it. He commented that most physicians are "babes in the wood" about the effects of atomic radiation, largely because the information is not available. He pointed out that at the moment "we are ensnared in an incongruous situation" wherein the physical scientist controls the "atomic pile of education and knowledge," while the practicing physician passively stands aside.

Vault for the Future

Science and *The Scientific Monthly,* in company with such journals as the *Saturday Review of Literature* and *Newsweek,* will be buried in the Vault for the Future, which was dedicated on 20 June at George Washington University. The vault will preserve for 100 years records of modern engineering achievement. It is located beneath the walkway in front of the university's Tomkins Hall of Engineering, which is now nearing completion.

The vault will contain contributions from 20 Government agencies and national and local societies. Each group invited to participate will place selected materials in one of 24 copper boxes, which will be sealed in the vault and marked by a granite block surmounted by a bronze plaque.

The boxes will contain such diverse items as documents and photographs, research reports, strain gages, ball bearings, gas turbine blades, a gyroscope, and ball point pens. The university plans to open the vault 100 years from today, so that engineers then can see this record.

TB and the Yellow Bacillus

A disease that resembles tuberculosis but is caused by an unknown bacillus was reported in the June issue of the *American Review of Tuberculosis and Pulmonary Diseases* (vol. 73, No. 6), journal of the American Trudeau Society. Lawrence E. Wood, Victor B. Buhler, and Ann Pollak of the University of Kansas, describe 17 patients infected with an acid-fast type of bacillus that has the same shape as the tubercle bacillus but which produces yellow cultures, whereas the tubercle bacillus is colorless. Another distinguishing characteristic is that the yellow germ does not produce disease in the guinea pig, although this animal is highly susceptible to tuberculosis.

Among the 17 cases described six had died, but it is not known whether one death was related to the disease. Five of the deaths, however, could be attributed to the disease resulting from infection by the yellow bacillus. At the time the report was prepared, four patients were well, another four were still under treatment, and three were no longer available for study.

Again, the "Abominable Snowman"

The "abominable snowman" still haunts the Himalayas. This creature, variously regarded as a bear, as a monkey, as a giant ape surviving as a relic of the ice age, as an animal hitherto unknown to science, or even, by arrant scoffers, as a pure myth [*Science,* **123,** 1024 (8 June)], continues to make the headlines. An Associated Press dispatch from Katmandu, Nepal, dated 10 June, states that Himalayan villagers claim to have found the body of an "abominable snowman" imbedded in the ice of a crevasse at the foot of Mount Makalu, a 27,790-foot peak on the Tibetan-Nepalese border. Furthermore, according to this dispatch, Peter John Webster, a British tea planter, hopes to go to Mount Makalu next year to investigate the villagers' story.

Webster, who has climbed extensively in the Himalayas, only recently crossed 20,000-foot Ambu Lapcha Pass to join the Swiss expedition that conquered Mount Everest. Once, while high in the Himalayas, he heard a whistling sound, which his guides believed to be the wail of the "snowman." Search of the area, however, revealed no evidence of such a beast.

Webster is skeptical about the existence of an "abominable snowman"; but, with true scientific spirit, he intends to investigate the reported body in the ice beside Mount Makalu. One hopes that he will take along a camera. Yet, whatever he may or may not find, it is not to be expected that the "abominable snowman" will desist from his gambols in the Himalayan snows. He is too well established a poltergeist to do that.—W.L.S., Jr.

Microwave Detection of Metallic Ions in Plant Material

Microwave developments during the war have made it possible to use microwave experiments widely, not only in physics and chemistry but even in biological investigations. H. Shields, W. B. Ard, and W. Gordy of Duke University report the "Detection of metallic ions and organic radicals in plant materials by microwaves" in the 26 May issue of *Nature.*

Materials taken from a plant or from the ground below were placed in a microwave absorption cell and studied at room temperature. In numerous plant substances, electron-magnetic resonances corresponding to those from manganese ions in aqueous solutions were detected (six equal components with a component spacing of 95 gauss). Therefore, the investigators conclude that the manganese ions found in plants may be dissolved in their water content.

In pine cones and pine needles, a single sharp line was superimposed on the manganese hyperfine structure. Similar resonances were found in fallen oak leaves, naturally dried ivy stems, and other apparently dead plant materials; this may be caused by bound or semibound oxygen.

A third type of resonance was observed in several plant materials. This was a broad resonance, which the authors tentatively attribute to cupric ions. Microwave detection of ions in plant material should become a useful tool for the plant physiologist or agriculturist.—K. L.-H.

Scientists in the News

JOHN J. DAVIS of Purdue University is retiring as head of the entomology department and the Purdue University Agricultural Experiment Station after more than 35 years of service. He will be succeeded as head of the department by JOHN V. OSMUN.

W. ALBERT NOYES, dean of the University of Rochester graduate school, has been named acting dean of the College of Arts and Sciences. He succeeds J. EDWARD HOFFMEISTER, who resigned the deanship in order to devote full time to the chairmanship of the department of geology and geography.

ALFRED M. BONGIOVANNI, associate professor of pediatrics at the University of Pennsylvania School of Medicine, has received the 1956 CIBA award of the Endocrine Society for outstanding research in human endocrine glands, particularly as they affect the development of the child. He was honored for his work on the chemical nature of adrenal cortex hormones and on the abnormalities in the biosynthesis of these hormones which lead to various adrenal diseases.

The award is made annually to a scientist under 35 years of age. It provides $1800, and $700 for expenses, should the winner decide to move to a laboratory other than his own for special research.

RICHARD M. NELSON, high-school science teacher of Kalispell, Mont., has been named the fifth "McCall's Teacher of the Year" by *McCall's* magazine. He was cited for "bringing the world of science to the attention of an agricultural and lumbering community—contributing to an eventual understanding of the atomic age by the layman." Recently, accompanied by two of his students, he was presented to President Eisenhower at the White House.

HOWARD O. McMAHON, science director of Arthur D. Little, Inc., has been elected a vice president of the company.

J. W. T. YOUNGS, professor of mathematics at Indiana University, has been named chairman of the department of mathematics and director of the Graduate Institute for Mathematics and Mechanics. The appointment consolidates the administration of the university's two divisions devoted to teaching and research in mathematics.

THOMAS H. CHRISTIE, chairman of the science department at Washington-Lee High School, Arlington, Va., has been selected by the Virginia Section of the American Chemical Society to receive its 1956 distinguished service award in recognition of his excellence in science teaching and his outstanding contributions in stimulating interest in science among high-school students.

Lehigh University has named HARVEY A. NEVILLE as vice president and provost and FRANK E. MYERS as dean of the graduate school. Neville, head of the chemistry department and former dean of the graduate school, will continue to direct the program of the Lehigh Institute of Research. Myers will continue to serve as head of the department of physics, a post he has held since 1947.

MAX A. WOODBURY, who formerly headed logistics research at George Washington University, has been appointed research professor of mathematics at the New York University College of Engineering. A specialist in probability, mathematical statistics, and computational methods, Woodbury devised the system by which the computer Univac predicted the outcome of the 1952 Presidential election on the basis of very early returns.

Besides developing the college's program in engineering statistics, he will direct the statistical, computational and mathematical work of the Engineering Research Division. This covers research in such fields as aerodynamics, navigation, electronics, meteorology, and oceanography.

WILLIAM N. LACEY has resigned as dean of graduate studies at California Institute of Technology in order to devote full time to teaching and research. He has been succeeded in the deanship by H. F. BOHNENBLUST, professor of mathematics at the institute since 1946.

The following are among those who have recently received honorary doctoral degrees.

Purdue University: HENRY R. KRAYBILL, vice president and director of research and education for the American Meat Institute Foundation.

Lawrence College: GERARD PIEL, publisher of *Scientific American*.

Cambridge University: DETLEV W. BRONK, president of the National Academy of Sciences.

West Virginia University: NATHAN I. HALL, vice president and director of Hughes Aircraft Company.

Oregon State College: WILLIAM J. KROLL of Corvallis, metallurgist; ROGER J. WILLIAMS, director of the biochemical institute at the University of Texas.

Union College: HENRY T. HEALD, chancellor of New York University; RUDOLPH A. SCHATZEL, vice president of Rome Cable Company; GLENN B. WARREN, vice president of the General Electric Company.

Alfred University: MARVIN J. UDY, Strategic Materials Corporation.

Hahnemann Medical College: FRANK M. PORTER, president of the American Petroleum Institute; FRANCIS BOYER, president of Smith, Kline and French Laboratories; DONALD GUTHRIE, surgeon-in-chief of the Guthrie Clinic at the Robert Packer Hospital.

A. M. GUREWITSCH, a physicist at the General Electric Research Laboratory, Schenectady, N.Y., has been appointed as one of the laboratory's European scientific representatives. Operating from the new G.E. research office in Zurich, Switzerland, Gurewitsch will travel throughout western Europe, attending scientific meetings and visiting laboratories that conduct fundamental research in areas that are of interest to the company.

ROBERT YORK, who since 1953 has been assistant director of the General Development Department of Monsanto Chemical Company in St. Louis, Mo., has been appointed the first Socony Mobil professor of chemical engineering at Cornell University. The new chair, made possible by a 5-year grant from Socony Mobil Oil Company, Inc., and intended primarily for undergraduate instruction, is believed to be the first of its kind to be established by an American university.

KARL S. QUISENBERRY has succeeded A. H. MOSEMAN as director of crops reseach in the U.S. Department of Agriculture's Agricultural Research Service. MARION W. PARKER, head of weed investigations in the Field Crops Research Branch, has replaced Quisenberry as assistant director. Moseman, who has directed USDA research in crop production since 1953, is resigning from Government service to accept a position with the Rockefeller Foundation as associate director for agricultural programs.

LLOYD A. HALL, technical director of the Griffith Laboratories, Inc., has been named recipient of the 1956 honor scroll award of the Chicago Chapter, American Institute of Chemists. The scroll will be presented next October at a testimonial banquet.

GAIL M. DACK, director of the Food Research Institute at the University of Chicago, received the Babcock-Hart award of the Institute of Food Technologists during its recent annual meeting. He read a paper on "Evaluations of microbiological standards for food."

JOHN L. NICKERSON, for the past 6 years professor of physiology at the College of Physicians and Surgeons, Columbia University, has been appointed chairman of the department of physiology and pharmacology at Chicago Medical School.

RILEY D. HOUSEWRIGHT has been appointed scientific director of the Army Chemical Corps Biological Warfare Laboratories at Fort Detrick, Md. Formerly he was chief of the Medical Bacteriology Division at Detrick. He succeeds JOHN L. SCHWAB, who was recently named deputy for scientific activities of the Army Chemical Corps Research and Development Command.

JAMES C. THOMSON, formerly director of the Nutrition Research Institute and professor of biochemistry and nutrition at International Christian University in Tokyo, and more recently nutrition consultant on the Joint FAO/WHO/UNICEF Pakistan Milk Survey Team, has returned to his position in Teheran, Iran, as World Health Organization nutrition consultant to the Ministry of Health of Iran.

J. PALMER SAUNDERS, formerly deputy chief of the Pharmacology Branch, Chemical Warfare Laboratories, Army Chemical Center, Md., has accepted appointment as executive secretary of the Pharmacology and Experimental Therapeutics Study Section, Division of Research Grants, National Institutes of Health.

RUFUS OLDENBURGER, director of research for the Woodward Governor Company, will join the Purdue University faculty on 1 Sept. as professor of engineering sciences and mechanical engineering.

Recent Deaths

ROBERT BENSLEY, Chicago, Ill.; 88; professor emeritus of anatomy at the University of Chicago; authority on cell structure; 11 June.

FREEMAN F. BURR, Wayne, Me.; 79; retired Maine state geologist and authority on Maine's natural resources; 8 June.

CLARENCE G. CAMPBELL, New York, N.Y.; 88; physician and specialist in anthropology and eugenics; 16 June.

CHARLES DERLETH, JR., San Francisco, Calif.; 81; retired chairman of the department of civil engineering at the University of California; 13 June.

LAWRENCE J. HERR, Westfield, N.J.; 57; civil engineer for Esso Research and Engineering Company; 12 June.

ERNST LEITZ, Wentzler, Germany; 85; president of the Leitz Optical Works; 15 June.

C(HAUNCEY) M. LOUTTIT, Detroit, Mich.; 54; chairman of the department of psychology at Wayne University; editor of *Psychological Abstracts*; 24 May.

CLARENCE LOWE, Johannesburg, Union of South Africa; 62; former director of the Archaeological Survey of South Africa; 17 June.

FRANCES E. McRAE, New York, N.Y.; 87; retired associate professor of chemistry at Hunter College; 11 June.

THOMAS H. McHATTON, Athens, Ga.; 72; professor emeritus and former head of the department of horticulture at the University of Georgia; 15 May.

Grants, Fellowships, and Awards

■ The Graduate Research Institute of Baylor University has announced the availability of assistantships for students working towards the M.S. and Ph.D. degrees in the basic fields of science related to modern medicine. Included are anatomy, microbiology, cytology, human genetics, immunology, and organic, bio-, and radiochemistry.

Because of the close connection between the institute and Baylor University Hospital and the Wadley Blood Center, an unusual opportunity is afforded students to conduct research on human pathologic states. For further information, address inquiries to Dr. Morton D. Prager, Baylor University Graduate Research Institute, 3600 Gaston Ave., Dallas, Tex.

■ The Alfred P. Sloan Foundation, Inc., has announced an expansion of its scholarship program. Originally limited to some 100 scholarship stipends tenable at four institutions, the program in the future will embrace 13 colleges and universities and make awards to some 240 students. Two institutions have been added to the program during the last month. They are the Case Institute of Technology and the Johns Hopkins University School of Engineering.

The 11 institutions already participating in the scholarship program are Albion College, Amherst College, California Institute of Technology, Cornell University, Dartmouth College, Massachusetts Institute of Technology, Oberlin College, Stanford University, Wabash College, and Williams College. By 1960, when this scholarship program is fully operative, it is anticipated that the foundation's annual expenditure will exceed $420,000.

In the Laboratories

■ The Ultrasonic Manufacturers Association has announced the formation of an Engineering Standards Committee. Composed of members from 17 ultrasonic manufacturers in the United States, this committee has been established to formulate engineering standards and practices for the industry.

■ The Gulf Research and Development Company, Harmarville, Pa., has announced that it has undertaken an expanded production research program, to be conducted by 150 scientists, engineers, and technicians, in an effort to improve the recovery of petroleum from oil fields. Specific aims include increasing the percentage of petroleum recovered from oil formations, and improving both the speed and the economy of drilling wells and producing and transporting oil and gas.

Two new buildings, to cost approximately $1.5 million, will house these activities, for which additional staff members are now being recruited. Both buildings are under construction. The smaller, for heavy drilling research, is scheduled for completion in August and the main building in January 1957.

The larger structure, of two-tone brick and steel frame, will be four stories high. It will include some 94 laboratories and offices, besides storage, utility, and service rooms.

The smaller structure, of concrete block and metal panels, will be built around an 80-foot derrick. Sliding roof panels will permit operation of the derrick. There will be a single floor, several offices, and a mud pit for mixing drilling mud. The area beneath the drilling platform is designed for setting up heavy test equipment, such as experimental drills and oil field rock cast in concrete for drilling rate studies.

■ A new firm, the New England Nuclear Corporation, 575 Albany St., Boston, has been formed by Edward Shapiro and Seymour Rothchild, former heads of the inorganic and organic chemistry departments of Tracerlab, Inc. The firm will specialize in the chemical aspects of radioactive materials and will manufacture labeled compounds, reference sources, and radioactivity devices.

Miscellaneous

■ The International Commission on Zoological Nomenclature has given notice that beginning 26 Dec. it will start voting on the following cases involving the possible use of its plenary powers for the purposes specified against each entry. Full details were published in the *Bulletin of Zoological Nomenclature* [**12**, pt. 3 (26 June 1956)]. (i) *Lepidurus* Leach, 1819, validation; *Triops* Schrank, 1803, determination of gender and designation of type species for (Cl. Crustacea, order Decapoda); (ii) APODINAE Hartert, 1897 (Cl. Aves), validation; (iii) *volvulus* (emend. of *volvulus*) (*Filaria*), validation of, as from Leuckart [1892] (Cl. Nematoda); (iv) *Asaphus* Brongniart, 1822, validation of and designation of type species for; *cornigerus* Schlotheim, 1820 (*Trilobites*), suppression (Cl. Trilobita). Comments should be sent as soon as possible to Francis Hemming, Secretary to the Commission, 28 Park Village East, Regent's Park, London, N.W.1.

■ The Fund for Peaceful Atomic Development, 2000 Second Ave., Detroit 26, Mich., has published a pamphlet entitled *Nuclear Science and Engineering Training in the United States* that is a listing of facilities at selected colleges and universities and at the national laboratories of the U.S. Atomic Energy Commission.

The publication has been prepared especially for the use of students from outside the United States who are interested in graduate training in this country. It should also be helpful to American students seeking unclassified training in nuclear science, engineering, radiological and health physics, isotope handling, and associated courses.

The information presented in the report was obtained almost entirely through questionnaires addressed to the institutions listed. The material is in summary form and is intended simply as a guide in selection of institutions for advanced training.

Reports

Colchicine-Induced Polyploidy in Chlamydomonas

Although the alkaloid colchicine has proved to be an effective agent for the induction of polyploidy in higher plants, comparable success has not been achieved with microorganisms. In a recent review of the literature, Eigsti (*1*) concluded that no substantial evidence existed for the induction of polyploidy in microorganisms with colchicine. However, a paper by Tschermak (*2*), not listed in Eigsti's review, reported mitotic metaphases with the doubled chromosome number in cultures of *Oedogonium* after treatment with colchicine.

The establishment of polyploid strains of microorganisms suitable for genetic analysis would be of considerable significance for studies of the physiology of polyploidy. In spite of previous unsuccessful attempts reported in the literature (*3*), a series of colchicine treatments was made (*4*) as part of a larger study of inheritance in *Chlamydomonas*.

Haploid vegetative cells of *C. eugametos* Moewus were exposed to concentrations of 0.01, 0.1, and 1.0-percent colchicine using standard microbiological spot-plate technique. Essentially no inhibition of growth or cell division was noted at 0.01 or 0.1 percent, but, in a narrow zone around the 1.0-percent solution, cell division was completely inhibited, yet cell enlargement proceeded, producing cells up to 10 times normal cell volume.

Figs. 1–6. Photomicrographs of two mitotic metaphase nuclei of *C. Reinhardi*: (1–3) three focal levels of a normal haploid nucleus; (4–6) three focal levels of a nucleus from a colchicine-induced diploid strain.

A study of this effect was made by fixing cells, in a solution of 3 parts ethanol to 1 part acetic acid, at intervals during a 55-hour continuous exposure to 1.0-percent colchicine. Using the selective staining method of De Lamater (*5*) it was possible to observe clearly, C-mitoses, polyploid nuclei, and multinucleate cells. A high degree of polyploidy was evident by 24 hours. The majority of treated cells had not undergone cytokinesis by the end of 55 hours and were many times the size of the untreated cells, which had essentially completed a series of five divisions by the end of 18 hours. These observations confirmed the efficacy of colchicine and suggested the possibility of obtaining polyploid strains in culture.

Haploid vegetative cells of *C. Reinhardi* Dang. were cultured under optimum growing conditions, in a nutrient solution (*6*) containing 1.0-percent colchicine. Cells were removed and plated in colchicine-free media hourly. Cells arising from single, treated cells were subcultured for further study. Optimum exposure time was not established, but 8 hours proved sufficient to induce a doubling of the chromosome number. On the basis of the results of prolonged exposure of *C. eugametos* to colchicine, it is felt that viable strains possessing higher degrees of polyploidy can be obtained.

Exact determinations of chromosome number were difficult, owing to the small size of the chromosomes and the lack of flatness of the metaphase plates. Schaechter and De Lamater (*5*) reported a chromosome number of 18 ± 2 for *C. Reinhardi* Dang. In the present study, approximately 16 chromosomes were observed in the normal, haploid, vegetative cells, while the number in the colchicine-induced diploid was in excess of 28 and not more than 34. Figures 1–3 show a typical metaphase plate of the control photographed at three focal levels. A metaphase plate of the colchicine-induced diploid, photographed at three focal levels is shown in Figs. 4–6.

Growth rates were determined for these two strains, both in light on an inorganic medium (*7*) and in the absence of light in the same medium plus 0.2-percent sodium acetate. Rapidly growing cultures were adjusted to a standard optical density and were used to inoculate test-tube cultures that were grown at a light intensity of 700 foot-candles and with continuous agitation. Growth was measured as optical density at 5600 A. Maximum growth rate was essentially equal for all cultures; however, growth of both strains, in the absence of light, was preceded by a 48-hour lag phase. Dry weight of cells centrifuged from illuminated, rapidly growing cultures was 2.8 mg/10 ml of culture for both strains. Calculations of dry weight per cell and volume per cell were made from cultures of the two strains which were in the logarithmic phase of development. The ratio, induced diploid to haploid, for these values was determined as 1.68 for dry weight and 1.65 for volume.

Preliminary studies have shown that the rate of synthesis of cell material per unit of dry weight of inoculum was essentially the same in both strains. However, when calculated on the basis of rate of synthesis per genome, the diploid strain is only 70 percent as efficient as the haploid strain. This was demonstrated by starting with inocula containing equal numbers of cells for both strains and with inocula of equal dry weights. In both cases, analysis of parallel cultures, interrupted in the logarithmic phase of growth, showed that synthesis in the diploid strain attained only 65 to 70 percent of that possible if the rate of synthesis per genome had been equal. This loss of efficiency may be a consequence of the lower surface to volume ratio of the diploid cells or may simply be the result of the alteration of the nucleus to cytoplasm ratio (*8*). In a recent comparison of autotetraploid and diploid yeasts (*9*), it is stated that 4N cultures produced about 1.76 times the dry weight of 2N cultures under equal circumstances. However, standardization of inoculum seemed poor in this test.

These preliminary studies are being expanded, and determinations of x-ray sensitivity, pigment production, and biochemical fractions of the haploid and colchicine-induced diploid strains are in progress.

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6. D. F. Wetherell and R. W. Krauss, *Carnegie Inst. Wash. Yearbook* No. 53, 180 (1954).
7. R. Sager and S. Granick, *J. Gen. Physiol.* 37, 729 (1954).
8. Although the number of genomes per cell is doubled, the dry weight per cell increases only about 1.68 times.
9. S. Duraiswami, *Current Sci. India* 20, 235 (1951).

23 February 1956

Stability of the Gene

The concept of the stability of the gene is one of the fundamental principles underlying the theory of the gene. According to Morgan (*1*), "Mendel's theory of heredity postulates that the gene is stable. It assumes that the gene that each parent contributes to the hybrid remains intact in its new environment in the hybrid. . . . If a black guinea pig is bred to a white one, the offspring are black. If these are inbred, the offspring are three blacks to one white. The extracted whites breed as true as the original race of whites. The white gene has not been contaminated by the black gene in their sojourn together in the hybrid."

The conclusion "that the white gene has not been contaminated" is an inference based on assuming a gametic ratio of 2 : 2 at every meiosis. The "area of inference" in current theory is defined in Fig. 1 (*2*). The genotypes of the sperm produced from the spermatocyte of a hybrid male are inferred by analysis of the offspring from a mating with a homozygous recessive female. Approximately one-half of the offspring show the dominant and one-half the recessive phenotype, supporting the view that one-half of the sperm carried the dominant and one-half the recessive gene. The identical result could have been obtained, however, if some spermatocytes were *XXXx*, while a similar number were *xxxX* (*X* and *x* indicating the dominant and the recessive alleles, respectively).

Actually, extensive data seldom show a precise 1 : 1 ratio in the zygotes. Data from an experiment involving 9027 *Drosophila* (*3*) (the female was heterozygous) revealed significant deviation from a 1 : 1 ratio. Small significant deviations from a 1 : 1 ratio are seldom mentioned by geneticists, but when irregular ratios are brought to attention, they are invariably considered to result from differential viability of genetically different classes of individuals (or diminished viability of the sperm or eggs carrying the gene involved). Differences in viability of the different classes of individuals are easily demonstrable and are assumed to be adequate evidence for the view that the stability of the gene has been maintained.

An alternative interpretation is equally probable. The 52 : 48 ratio could have been produced by a few *XXXx* spermatocytes. In Fig. 1, the area of inference is enclosed in a broken line to emphasize that direct information is not available bearing on the genotypes of the sperm produced by individual spermatocytes. The view that the gametic ratio in every heterozygous spermatocyte is 2 : 2 is clearly an inference.

Direct evidence from tetrad analysis of a *Saccharomyces* hybrid heterozygous for the gene controlling maltose fermentation contradicts this inference (*4*). A population of 920 gametes produced 48.5 ± 1.65 percent *X* : 51.5 ± 1.65 percent *x*, which does not differ significantly from a statistical ratio of 50 percent *X* to 50 percent *x*, but direct evidence revealed four unexpected kinds of tetrads: *XXXX*, *XXXx*, *xxxX*, and *xxxx*. The irregular tetrads are of two types—those that contain an excess of dominant genes over the expected 2 : 2 and those that contain an excess of recessive genes over the expected 2 : 2. Each zygote was heterozygous for two pairs of genes, and the tetrads that contained more than two dominant maltose genes also contained more than two dominant α-methyl glucoside genes. This dependence is interpreted to mean that the excess of dominant genes was produced by the segregation of a tetraploid zygote produced by the fusion of cells of like mating type. Specific examples of tetraploid segregations have been described by Lindegren and Lindegren (*5*) and by Roman, Hawthorne, and Douglas (*6*).

Although some tetrads containing an excess of recessive genes are susceptible to this explanation, extensive analysis of a single irregular tetrad (*7*) has shown that polyploidy was not involved, and the irregular ratio has been interpreted to result from gene-conversion. Many ingenious hypotheses have been proposed to explain the unexpected types on the assumption of genic stability. This procedure is based on the assumption that the gametic ratio at every meiosis is 2 : 2. The inadequacy of these hypotheses will be dealt with elsewhere; the purpose of the present paper is to point out that direct evidence takes priority over inference. Genic instability is expressed in the following ways.

1) Some genes are relatively stable and rarely convert. The gene controlling the synthesis of adenine has undergone conversion only rarely (*7*). Others are highly unstable; the *MG mg* alleles undergo conversion frequently.

2) Genes may be markedly stable in one mating and unstable in another. The *MA/ma* and *MG/mg* alleles behaved very differently in different families (*4*).

3) Some genes have several manifestations, some of which are extremely stable, while others convert frequently. The *MZ* allele in *Saccharomyces* (*8*) has at least five manifestations involving ability to adapt to maltose, turanose, sucrose, α-methyl glucoside, and melezitose. The ability to adapt to maltose is lost rarely, while the ability to adapt to melezitose is lost readily. It is possible that most genes have several manifestations that differ in stability and that a gene is usually identified by its most stable manifestation.

4) Some genes are phenomenally stable and have only rarely or never revealed detectable conversion, even after analysis of hundreds of tetrads. (It

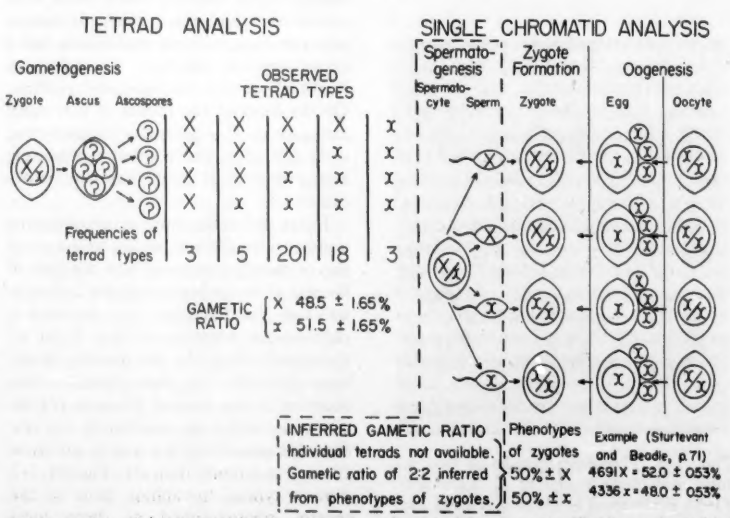

Fig. 1. The differences between tetrad analysis and single chromatid analysis; the "area of inference" in single chromatid analysis is defined by a broken line.

is important to point out again that instability can be detected only by tetrad analysis.) The genes controlling mating type, uracil synthesis, and copper sensitivity are of this type.

Geneticists prefer to work with stable genes, especially in map construction. Genes that occur with higher than the expected frequency in a population are called genes of "high penetrance." It is possible that deviations in "penetrance" may involve gene-conversion. Much of the early work in genetics was devoted to the selection of stocks carrying "good" genes. Although value judgments are rarely expressed in print, it is interesting to note that even the most astute and objective workers (*9*) have made them: ". . . it is a simple matter to determine the relation between different types of double exchanges, though this has not as yet been *satisfactorily* done, because of lack of *good* genetic characters localized within one arm of a single chromosome."

It is difficult to say how much of the attitude toward gene conversion has its origin in the preference of the geneticist for "good" genes that behave "properly." The designation genetical "marker" may provide a key to this psychological problem, since the term implies a relatively solid monument not subject to capricious change.

The theory of gene-conversion proposed by Winkler (*10*) is now known to be invalid in its original form, since it proposed to explain all recombinations by gene-conversion. The experiments presented by Stern (*11*) as refutation of Winkler's theory proved that crossing-over occurred but failed to prove that conversion did not. Stern showed that *all* recombination was not conversion, but his conclusion that this excluded the possibility of gene-conversion was incorrect. The climate of genetical thought in the 1930's was favorable to Stern's argument, and its fundamental fallacy was not discovered. The failure to evaluate it critically resulted in the persistence of the dogma of genic integrity and delayed the demonstration of gene-conversion.

Although geneticists have resisted acceptance of the simpler interpretation of the direct data contradicting the assumed 2 : 2 ratio at each meiosis, they have accepted evidence indicating that genes can be transformed from one type to another (i) by treatment with a nucleic acid extract from cells carrying the complementary allele or (ii) by infection with a virus that previously had infected a cell carrying the complementary allele. These phenomena of transformation (i) and transduction (ii) are gene-conversions in an operational sense (if genes are, in fact, involved) mediated indirectly through chemicals and viruses. The readiness with which these phenomena are accepted as evidence of gene-change and the resistance to the direct evidence that two genes present in the same nucleus can undergo conversion is evidence of the attitude that considers an old accepted concept more reliable than a new one.

The chronological sequence in which scientific discoveries are made has a direct bearing upon the way in which they are interpreted. Because the concept of genic stability preceded the discovery of direct data revealing true gametic ratios, the climate of genetical thought has not been receptive to direct evidence contradicting the concept of genic stability. Data that confirm a well-established theory are generally accepted without critical evaluation. The established concept serves as a fundamental point of reference, and new data are judged by the closeness with which they fit the established point of view. In genetics the stability of the gene is such a point of reference, and other data are evaluated by considering whether or not they support this fundamental concept. This has produced a system of circular reasoning in which experimental data are evaluated by the precision with which they confirm the concept of genic stability and this "confirmation" is taken as evidence for the reality of the concept.

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Localization and Quantitation of Water in Biological Samples by Historadiography

The development of the interference microscope has made it possible to determine the dry weight and water content of cells and parts of cells (*1*). Although this technique is especially well suited for work on isolated cells, it is perhaps less successful with larger samples, such as microtome sections of tissues fixed by the freeze-drying method. On the other hand, soft x-ray absorption has been applied with particular success to the measurement of dry weight in both tissue sections and cytological preparations (*2, 3*), but heretofore it has not been possible to use this technique for a comparable measurement of water. An instrumental improvement (*4*) by which the sample is permitted to remain at room conditions outside of the x-ray tube has now opened the way for an extension of this method to include the determination of water *in situ*. This report (*5*) is concerned with the theoretical basis for the measurement of the water and the experimental method for each of two procedures that have been devised.

1) If microradiograms are made by the conventional method (*3*), with the newer equipment (*4*), of a fresh-frozen biological sample before and after removal of water by freezing-drying, densitometric measurements of the photographic images will permit calculation of the respective masses and, therefore, of water content by difference. This is based on the following.

$$I_T = I_o e^{-[(\mu/\rho)_s \cdot m_s + (\mu/\rho)_w \cdot m_w]} \quad (1)$$

where the subscripts T, s, and w refer to total sample before dehydration, organic substance in the sample, and water, respectively, so that I_T and I_o represent the x-ray intensities transmitted and incident; and where (μ/ρ) is the mass absorption coefficient (that is, μ is the linear absorption coefficient and ρ the density), and m the mass per unit area. Since the extinction, E_T, equals $\ln(I_o/I_T)$,

$$E_T = (\mu/\rho)_s \cdot m_s + (\mu/\rho)_w \cdot m_w \quad (2)$$

After the removal of the water, the extinction becomes

$$E_s = (\mu/\rho)_s \cdot m_s \quad (3)$$

Likewise we can write

$$E_w = (\mu/\rho)_w \cdot m_w \quad (4)$$

and therefore

$$m_w = \frac{E_T - E_s}{(\mu/\rho)_w}. \quad (5)$$

The values of E_T and E_s obtained by measurement of I_o, I_T, and I_s (the intensity transmitted by the dried sample), permit the calculation of m_w, since $(\mu/\rho)_w$ can be calculated from standard tables.

For the experimental procedure, it would be preferable to freeze the fresh specimen suddenly in isopentane, dichlorodifluoromethane, or any of the other liquids commonly used for this purpose, which has been cooled by liquid nitrogen. The frozen specimen may then be sectioned in a cryostat or cold room and the sections used to obtain a microradiogram with x-ray apparatus inside of the cold chamber. It is essential that the

material does not thaw after the initial freezing, and that the microradiogram be taken before appreciable evaporation can occur. Specimens that do not require sectioning (for example, single nerve or muscle fibers) can be employed in a similar way. After the microradiogram has been taken, the sample is dried while it is still frozen to minimize morphological change (*6*), preferably with modern equipment (*7*), and the desiccated sample is used to obtain the second microradiogram.

2) If a microradiogram of only the dried sample is taken with 8 A or softer x-rays, the photographic positive can be taken as a true representation of the dry matter, since the microradiographic method of weighing cell structures gives the weight per unit area. The negative, however, will approximate a representation of the water: The "effective thickness" of the dry matter (t_s) in a given structure equals m_s/ρ_s, so that the "thickness" of the water present in the fresh material is

$$t_w = t_T - m_s/\rho_s, \qquad (6)$$

where t_T is the measured total thickness of the fresh sample. The mass of water (density equals 1) per unit area then is

$$m_w = t_T - m_s/\rho_s. \qquad (7)$$

It can be shown that the total x-ray extinction of a fresh tissue section of unit thickness changes relatively little with the varying proportions of water and dry substances common to soft tissues. Therefore, as was pointed out before, a photographic negative of a microradiogram showing the distribution of dry mass will show the distribution of water.

The application of procedure 2 is illustrated by the following. If earlier data on the dry weight of cells in dog gastric mucosa, obtained by microradiography of frozen-dried tissue sections (*8*), are substituted in Eq. 7, assuming $\rho_s = 1.3$, the approximate water content of the chief cells, epithelial cytoplasm, and parietal cells is 70, 76, and 85 percent, respectively. Similarly, if earlier data on the dry weight of ventral horn cells in the cat spinal cord (*9*) are used, calculations of the water content give 30, 65, and 75 percent for nucleolus, cytoplasm, and nucleus, respectively.

Procedure 1 is the more unequivocal, but it has the disadvantage of requiring a microradiogram of the fresh-frozen sample in addition to one of the dried sample. Although procedure 2 requires only the latter, the thickness of the fresh sample must be accurately known, since this will usually be 2 to 5 times the "effective" thickness of the organic material —that is, (m_s/ρ_s). A newer method permits the measurement of the thickness of a 5-μ section to within a few percent (*10*), while the older method of measurement by focusing on the upper and lower surfaces with a microscope usually involves an error of about 10 percent (*11*). Only a small error will result from the common deviations in the assumed value of 1.3 for ρ_s.

In both procedures it is necessary to consider the morphological effects of the drying process. Although freezing-drying minimizes these, the use of imbedding media may involve loss of substance on removal of the media. Whether or not such a loss is significant will depend on the nature of the specimen and of the medium. For frozen-dried gastric mucosa that is imbedded in paraffin, the deparaffinizing by xylol has no appreciable effect, owing to the low fat content of this tissue. Chemical fixatives are to be avoided, because they produce structural distortions and also affect the quantity of substance remaining.

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Biosynthesis of Pelargonidin-3-glucoside-C^{14}

In connection with current research conducted in this department on the stabilization of color in strawberry preserves (1, 2), it was desirable to obtain a quantity of C^{14}-labeled strawberry pigment to facilitate studies of its degradation (*3*). In view of the complex structure of the major strawberry pigment, pelargonidin-3-glucoside (3,5,7,4′-tetrahydroxyflavylium chloride 3-beta-glucoside), biosynthesis of the compound seemed more practical than its synthesis by conventional chemical means (*4*).

Several means of introducing C^{14} into the growing strawberry plants were considered. They included (i) exposure of the plants to $C^{14}O_2$ in a closed system, (ii) submersion of the roots in synthetic nutrient media incorporating C^{14} in an absorbable form, (iii) direct injection of glucose-C^{14} solution into stems of fruit during the final stages of berry maturation, and (iv) diffusion of glucose-C^{14} by direct immersion of the berries in a solution of radiosugar.

In view of the low activity of radiocarbon and the limitations on the amounts of tracer compounds used (microcurie levels were used in all preliminary experiments), only those methods appearing to channel the label most directly into the fruit were first tried. Injection of glucose-C^{14} solutions into either stems or fruits was unsuccessful owing to the absence of cavities in these that are capable of storing even small amounts of solutions. A slow, drip-feeding of glucose-C^{14} solution into the stems was equally unsuccessful. The diffusion of glucose-C^{14} into the green berries by direct immersion was not attempted because a preliminary trial, using an inactive glucose solution, resulted in a deleterious effect on the fruit.

However, two of the methods tried did result in the assimilation of the radiocarbon with no apparent injury to the plants. These methods were the exposure of strawberry plants to $C^{14}O_2$ and the application of crystalline, uniformly labeled glucose-C^{14} to freshly cut sections of fruit stems. In both instances, it was possible to extract, using suitable solvents, the pigments that were present and, upon chromatographic purification, to isolate the crystalline pelargonidin-3-glucoside-C^{14}. To eliminate the possibility that the pigment was merely contaminated with some of the radioglucose when the C^{14} was introduced in this form, tagged glucose was added to a portion of inactive juice from which the pigment was then also extracted. The absence of activity in pigment recovered from this sample is indicative of the effectiveness of the purification procedure used. Through acid hydrolysis of the active pelargonidin-3-glucoside to the pelargonidin, it was also established that the activity was uniformly distributed throughout the pigment molecule and not merely attributable to the sugar moiety.

The labeled sugar was introduced into the plant by placing the dry crystals in small, longitudinal, V-shaped grooves that were cut in the stems and allowing the plant juices to dissolve them. Forty grams of ripe strawberries was harvested from plants to which about 2μc (about 80 mg) of glucose-C^{14} was administered.

The berries were frozen and thawed, and the major pigment was isolated from the hand-expressed juice by the paper chromatographic method described in a subsequent paragraph. About 8 mg of crystalline pelargonidin chloride-3-monoglucoside-C^{14} was obtained.

Individual strawberry plants were covered with glass bell jars into which $C^{14}O_2$, generated by the action of HCl on $Na_2C^{14}O_3$ or on $BaC^{14}O_3$, was introduced to create an atmosphere of about 0.8 percent CO_2. In a preliminary greenhouse experiment, 2 μc of $C^{14}O_2$ was administered to a single plant in two doses within 3 weeks. During the time between the two doses, the plant was left uncovered for 4 days, because a few necrotic spots had appeared on its leaves. Fourteen grams of ripe berries was obtained from this plant, and about 3 mg of tagged pigment was crystallized from them.

In the subsequent field experiment, 1 mc of $C^{14}O_2$ was similarly applied over a 4-day period to four strawberry plants located in an outdoor bed. From the berries that were harvested from these plants 59.5 mg of pelargonidin-3-glucoside-C^{14} was recrystallized.

Juice from the strawberries was acidified to contain 1 percent HCl, and the resulting solution was extracted with 1-butanol. On treating the alcohol extract with petroleum ether, the water was separated from the butanol in which it had been dissolved. This aqueous phase contained all of the colored matter present and could be concentrated under vacuum at temperatures below 50°C to almost one-third of the original volume. The concentrate was streaked on strips of Whatman No. 1 or 4 paper, the resulting bands being dried immediately after application. After ascending development for 12 to 16 hours, using a solution of 1-butanol, acetic acid, and water (40/10/50, respectively, by volume) as the solvent, the anthocyanin bands were fully separated (*5*). Bands corresponding to pelargonidin-3-glucoside were cut out and eluted by immersing one end of each strip in a beaker of methanol that contained a trace of HCl and allowing this solvent to descend by capillarity into a lower beaker. The methanolic eluate was evaporated under vacuum, leaving a noncrystalline residue, which was redissolved in 1-percent HCl and chromatographed by the same method as that employed for the aqueous concentrate. Methanolic eluates, obtained from pelargonidin-3-glucoside bands from the second chromatograph, were acidified with HCl and allowed to evaporate slowly at room temperature. Red, needlelike crystals of pelargonidin-3-glucoside-C^{14} were obtained.

Measurements of activity were carried out using a Tracerlab Autoscaler equipped with a thin (1.4 mg/cm²) end-window Geiger-Müller tube, except for the determination of activity on the pigment resulting from the 1-mc $C^{14}O_2$ experiment. For this, a Tracerlab Superscaler equipped with a windowless, gas-flow counter was employed. Specific activities for the pigment samples recovered in the microcurie experiments were low, but counts were statistically significant at the 1-percent level. Pigment from strawberries harvested from the plants treated with glucose-C^{14} showed a specific activity of 379 ± 7 disintegrations per minute, per milligram of pigment. Pigment from the plant exposed to 2 μc of $C^{14}O_2$ showed a specific activity of 951 ± 19 disintegrations per minute, per milligram. These correspond to yields, based on activity, of 0.068 percent for the glucose-C^{14} method and 0.064 percent for the $C^{14}O_2$ method .

In the preparatory run, utilizing 1 mc of $C^{14}O_2$, pelargonidin-3-glucoside-C^{14} with a specific activity of 1512 disintegrations per minute, per milligram was obtained. The percentage yield, based on activity for this experiment was 0.004.

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12 March 1956

Optical Isomerism and Pharmacological Action, a Generalization

The study of the biological activity of drugs with optical isomerism has been unduly influenced by the known optical specificity of the amino acids, wherein, for example, *d*-serine is reported not only to be inactive but to produce kidney damage (*1*). *d*-Glutamic acid is reported to be cyclicized into a pyrrole compound and excreted in the urine (*2*). Such complete failure of the body to utilize the unnatural isomer might be expected with chemicals such as amino acids, which are the building blocks for proteins. Drugs, and even the naturally occurring humoral agents, probably act by modifying cellular responses and are thus not as geometrically specific as are the amino acids. Yet, one finds frequently in the pharmacological literature the statement that the active form of the drug is the *l* or *d* isomer without adequate trial of higher doses of the more inactive isomer.

Consideration of the specificity of the optical isomers of thyroxin is omitted from this report, since the asymmetric carbon atom occurs at the portion of the molecule that may be involved in synthesis of the thyroxin molecule into cellular proteins where the optical configuration may be as crucial as that of the amino acids. Several individual factors that may dominate in the drug action of optical isomers also have been omitted from consideration in this generalization. These factors are (i) rate of absorption or destruction of the isomers, (ii) competitive inhibition between isomers, (iii) molecular size such as *d-l* complex formation by hydrogen bonding between isomers, (iv) affinity for the receptors of the isomers, (v) differential penetration to the site of drug action, and (vi) the possible racemization by the body of the less active isomer.

Several years ago we were disappointed when the anticonvulsant *d*-atrolactamide was found to have a ratio of potency only 1.68 times greater than that of *l*-atrolactamide. This difference is easily measurable in terms of the LD_{50} in the mouse and is a statistically significant difference, as is shown by the following oral LD_{50}'s and their standard deviations: *d,l*-atrolactamide, 1.86 ± .07 g/kg; *d*-atrolactamide, 1.39 ± .04 g/kg; and *l*-atrolactamide, 2.33 ± .06 g/kg (*3*). However, atrolactamide as an anticonvulsant is relatively nonpotent in that it must be given in a dose of 1.5 g four times daily to control the seizures of epileptic patients. In retrospect, it becomes clear that potency per se, as expressed by the LD_{50}, is probably a measure of the degree of reactivity of the drug with cells or enzymes. Therefore, with a nonpotent drug, such as atrolactamide, the degree of geometric conformation to the locus of action must be relatively poor and, hence, would not be greatly influenced by the optical isomerism of the compound.

Since effective dosage of a drug is a measurement of potency, the dose can be used as an approximation of this geometric conformation, and the postulate can be made that the lower the effective dose of a drug, the greater the difference in the pharmacological effect of the optical isomers. In order to document this thesis, one would wish to have LD_{50}'s in the same species of animal for all of the commonly used drugs that can exist as *d* and *l* isomers. However, a survey of the literature does not provide such data

Table 1. Mouse LD_{50}'s (in milligrams per kilogram) for isomethadone.

Injection type	Isomer		Isomeric ratio
	l	*d*	
Intravenous (90 sec)	18.0 ± 1.8	38.8 ± 1.1	2.16
Intravenous (120 sec)		54.0 ± 2	3.0
Intraperitoneal	25.5 ± 2.4	73.1 ± 5.7	2.9
Subcutaneous	49.0 ± 2.7	155.1 ± 14.2	3.2
Subcutaneous	60	150	2.5 (Eddy)
Oral	81.1 ± 6.2	227.7 ± 10.8	2.8

for a single animal species by a uniform route of administration.

This scarcity of data is, in part, owing to the fact that the intravenous route of administration does not differentiate between the pharmacological effect of optical isomers (*4*). We have determined the LD_{50}'s in milligrams per kilogram for isomethadone in the mouse that are presented in Table 1.

The data agree with the findings of Eddy (*5*) for subcutaneous toxicity in the mouse. These data indicate that any route of administration will disclose a constant difference between the *d* and *l* isomers of isomethadone. The intravenous route approaches the discrimination of the intraperitoneal route if the rate of injection is slower than the usual 90-second interval. Conversely, published data on the intravenous route of administration that does not discriminate between *d* and *l* isomers may be correlated with the rapidity of injection wherein the drug affects nonspecific vital centers rather than those specific vital centers that can be affected by the optical configuration.

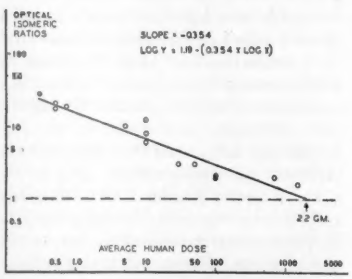

Fig. 1. Decrease in isomeric ratios with decrease in drug potency. The geometric ratio between the potency of the optical isomers is plotted in logarithmic units on the ordinate. The average human dose in milligrams is plotted in logarithmic units on the abscissa. The points for the 14 drugs plotted may be read from left to right as follows: norepinephrine 27 (*9*), atropine 20 (*11*), epinephrine 18.5 (*12*), scopolamine 17 (*11*), Dromoran 10 (*13*), methadone 6 (*14*), amphetamine 12 (*15*), and methamphetamine 8 (*16*), isomethadone 3 (*17*), ephedrine 3 (*18*), paired points Nirvanol and Mesantoin 2 (*19*), quinine (*20*), quinidine 2 (*21*), and atrolactamide 1.68 (*3*). The relationship may be expressed as $\log Y$ (isomeric ratio) $= 1.19 - [0.354 \times \log X$ (human dose)]. The *X*-axis intercept is the human dose of a theoretical drug with no measurable difference between optical isomers. An intercept with the *Y*-axis is not drawn, since future work with more potent drugs may prove that the regression line approaches the *Y*-axis asymptotically.

Figure 1 shows that there is a steady decrease in the isomeric ratios with the increase in the total dose needed to produce an effect in man. In each instance the optical isomeric ratio is obtained by dividing the effective dose of the less active isomer by the effective dose of the more active isomer without regard to actual optical rotation.

In choosing isomeric ratios for Fig. 1, preference was given to activity in pharmacodynamic tests and to oral or subcutaneous LD_{50}'s. The straight line resulting from a log-log plot is calculated by the method of least squares. The difference in pharmacological activity of the isomers is greatest with norepinephrine, epinephrine, and atropine, where the dose used in man is in the neighborhood of 0.25 to 1 mg. (*l*-LSD-25 has been tried in man in a total dose of only 0.150 mg.) Atrolactamide, a nonpotent drug, in a dose of 1.5 g, has the smallest isomeric ratio. The arrow indicates the intercept of the regression line with unity, which is at a dose of 2.2 g. This is the dose of a theoretical drug that would show no detectable effect of isomers.

Another nonpotent drug, camphor, is reported to have no difference in the pharmacological effect of its isomers. This observation should be tested by more accurate modern methods. In the case of the sympathomimetic amines, sufficient data are not available to provide a separate graphing of their isomeric ratios. When data are available, these amines must, of necessity, be divided into those that are mainly pressor and those that are mainly stimulant. Cobefrine with an isomeric ratio of 200 (*6*) and isopropylarterenol with an isomeric ratio of 1100 (*7*) appear to be exceptions to the foregoing generalization. However, Furchgott (*8*) estimates a fourfold greater affinity of isopropylarterenol for depressor receptors compared with epinephrine. Stimulant pressor amines, such as amphetamine and methamphetamine, which have the brain as their principal locus of action, show a greater difference in isomeric ratios for the central nervous system (approximately 6 to 12) than for the blood pressure response (approximately 2). If one accepts the foregoing premise, we can now postulate that the geometric conformation of a central nervous system stimulant pressor amine is more critical for the brain than it is for the vascular smooth muscle.

The study of Luduena *et al.* (*9*) is another interesting example of this greater geometric conformation in selected tissues of the body. In their studies on *d*- and *l*-norepinephrine they found a 1/15 ratio of vasoconstrictor potency for the perfused rabbit's ear and a 1/60 ratio for inhibition of the rabbit ileum. If the isomeric ratio is a measurement of geometric conformation to the site of action, these data might indicate that the molecular configuration of norepinephrine is much more specific for the smooth muscle of the intestine than for the smooth muscle of the arterioles. Similarly, the isomeric ratios of the action of epinephrine and norepinephrine at sympathetic nerve endings might determine which of these two sympathins has the more critical geometric conformation.

This generalization might be used in the future to determine the relative degree of geometric conformation of a drug to the specific tissue under test. In other words, the greater the difference between the pharmacological activity of the *d* and *l* isomers the greater is the specificity of the active isomer for the response of the tissue under test (*10*).

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2 February 1956

Photoreactivation of Ultraviolet-Inactivated Diphosphopyridine Nucleotide

Available information suggests that the site of photoreversible ultraviolet injury may be in a nucleotide, or in a compound containing a nucleotide, or in more than one such compound (*1*). It is further suggested that the substance is associated in some basic way with a diversity of cellular activities. The phosphopyridine nucleotide coenzymes, which are associated with a variety of hydrogen-transfer reactions, meet these specifications. The fact that a triosephosphate dehydrogenase-diphosphopyridine nucleotide complex, which loses activity in preparation, may be reactivated by light (*2*) suggests that diphosphopyridine nucleotide (DPN) may be involved. This report deals with a study of photoreactivation *in vitro* of DPN that has been partially inactivated by ultraviolet radiation (*3*). Some of the experiments discussed have been reported previously in abstract form (*4*).

Solutions of DPN (*5*) were prepared at concentrations of 1/5000 or 1/10,000 in 0.1*M* phosphate buffer at *p*H 7. The source of ultraviolet radiation (UV) was a Westinghouse Sterilamp (emitting mainly $\lambda = 2537$ A), and the source of visible light (VL) was a General Electric CH-4 spotlamp. A Corning No. 3060 glass filter, which transmits no short ultraviolet waves, and 3 in. of water were always interposed between the CH-4 lamp and solutions being exposed to VL. In typical experiments, samples were withdrawn from stock DPN solutions and were exposed to UV, to VL, or to UV and VL or were retained as unirradiated controls. Samples were irradiated in flat glass dishes with quartz covers (Vaseline sealed to prevent evaporation). Solutions were stirred with glass-enclosed magnetic fleas. The ability of DPN to accelerate the reduction of hog- or rat-liver extracts was used as the criterion of the activity of samples.

Four series of experiments are reported here. For series I, II, and III, hog liver was ground and mixed with equal parts phosphate buffer in a Waring Blendor, filtered through a clean laboratory towel, and stored frozen until used. For series IV, rat liver was prepared in the same way, except that, after being filtered through cloth, it was filtered twice through analytic-grade filter paper prior to freezing, and again after thawing, just prior to use.

In series I, irradiation periods of 2 hours were used for UV and for VL. In series II, exposure periods were 4 hours for UV and 2.5 hours for VL. The series-III samples were exposed to UV for 22 hours and to VL for 2 hours, and series-IV samples were exposed for 75 hours to UV and for 2 hours to VL. The experiment was repeated four times in series I, III, and IV and three times in series II. The direction and magnitude of result were consistent in each series of experiments.

Liver preparations were placed in Thunberg tubes. Equal amounts (1 or 2 ml) of methylene-blue solution (1/3000 in series I, II, and III; 1/5000 in series IV) and DPN solutions (variously treated) were placed in the caps. Control tubes were always run with buffer substituted for the added DPN solution. Tubes were evacuated of air, and their contents were mixed. Then the mixtures were incubated in a water bath at 30°C while achromic times were being determined. The average values for achromic times are reported in Table 1. Thunberg tubes from an experiment in series IV are shown in Fig. 1 as they appeared after 20 minutes of incubation.

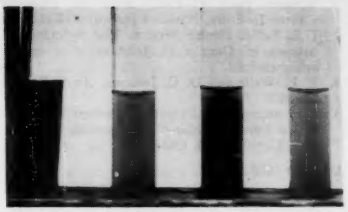

Fig. 1. A point of interest in a representative experiment. Thunberg tubes from an experiment in series IV, photographed after 20 minutes of incubation. Tubes were immediately returned to the water bath for the remainder of the incubation period. The tubes, from left to right, respectively, contain: No added DPN (achromic time, 100 min. +); untreated DPN (16 min.); UV-irradiated DPN (29 min.); DPN irradiated with UV + VL (20 min.). Photoreactivation is demonstrated by accelerated methylene-blue reduction in the fourth tube.

Liver preparations that received no added DPN reduced methylene blue slowly (series I, II, and III) or not measurably (series IV). In each experiment, the rate of decolorization was greatly accelerated by the addition of unirradiated DPN. Partial inactivation of DPN by UV was indicated by reduction of this acceleration in comparison with unirradiated controls. Visible light alone did not alter the activity of DPN. Photoreactivation of DPN samples that had been partially inactivated by ultraviolet radiation was apparent when UV treatment was followed by VL treatment. The photoreactivation of ultraviolet-inactivated diphosphopyridine nucleotide is of considerable interest as a possible model for interpretation of photoreactivation *in vivo*.

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Table 1. Data for experiments on photoreactivation of DPN *in vitro*. All values are averages of several experiments.

Experiment series	Achromic times (min)					Photoreactivation (min), UV − (UV + VL)
	Buffer only	Treatment of DPN				
		None	With VL	With UV	With UV + VL	
I	16.50	3.69	3.63	4.88	4.63	0.25
II	17.67	7.83	7.83	8.83	7.92	0.91
III	21.25	6.31	6.44	10.75	9.72	1.00
IV	78+	20.25		31.13	24.00	7.13

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1 March 1956

Serum and Liver Transaminase Activities in Experimental Virus Heptatitis in Mice

An increase (20- to 40-fold) in the aspartic-ketoglutaric and alanine-ketoglutaric transaminase activities of the serum in human epidemic virus hepatitis was found by us (*1, 2*). Later, aspartic-ketoglutaric transaminase activity in epidemic hepatitis was investigated by Wróblewski and LaDue (*3*), and comparable results were obtained.

No such increase has been found in any other type of icteric or anicteric liver diseases that were investigated by Wróblewski and LaDue (*3*) and by us (*1, 2*), with the exception of myocardial (precocious) infarction (*4*). Furthermore, these authors found an increase in the aspartic-ketoglutaric transaminase activity of serum both in cases of carbon tetrachloride poisoning in human beings and in cases of experimental carbon tetrachloride poisoning in mice (*3*).

In epidemic hepatitis, the increase in alanine-ketoglutaric transaminase activity is more consistent than the increase in aspartic-ketoglutaric activity. Consequently, the ratio of aspartic-ketoglutaric transaminase activity to alanine-ketoglutaric transaminase activity (As-K/Al-K) falls from the normal (mean) value of 1.3 to 0.64 in acute epidemic hepatitis (*1, 2*). Such a pattern is retained by the serum of a patient during his convalescence, when the absolute values of the enzymatic activities of the patient's serum are no longer diagnostically significant. We have suggested that such enzymatic determinations could be of use as a diagnostic test for human epidemic hepatitis (*1*). Our later experiments (63 cases of epidemic hepatitis) fully confirm our first results (*5*).

Questions have arisen with regard to the following: (i) whether the increase of the enzymatic activities is really related to the destruction of parenchymal liver cells as suggested by us and others (*1–5*); (ii) whether such enzymatic variations are common features of all human (epidemic, yellow fever, infectious mononucleosis, and so on) and animal virus hepatitides; (iii) whether enzymatic variations that are observed in serums are associated with variations in the same activities in liver tissue; (iv) whether the possible enzymatic variations in liver tissue are analogous or opposite to those in serums from the same subjects.

The present results (Table 1) concern two enzymatic activities of the livers and serums of mice infected with 1000 LD_{50} of hepatitis virus (MHV-3 Craig, of Gledhill and Andrewes, *6*) and killed on the fourth day of the disease (*7*). Determinations were made according to Tonhazy, White, and Umbreit (*8*).

Determinations were made of enzymatic activity in homogenates of liver tissue from each of 15 infected mice and each of 15 normal mice and in five pools of serums from normal mice and five from infected mice. Each pool contained a mixture of serums from three animals. The results obtained led us to the following conclusions:

1) An increase is shown in the investigated transaminase activities in the serums of the animals experimentally infected with MHV-strain virus. This increase is comparable to that observed in human beings with epidemic hepatitis. Furthermore, the afore-mentioned decrease in the value of the As-K/Al-K ratio is found in the serum both in cases of human hepatitis and cases of experimental hepatitis in mice.

2) The variation in either of the transaminase activities in the liver (both decrease) of an animal is opposite to the variation in the analogous transaminase activity in the serum of the same animal but roughly proportional to the latter in magnitude. The decrease in the alanine-ketoglutaric transaminase activity in livers and the increase in this activity in serums are more pronounced than the changes in activities of aspartic-ketoglutaric transaminase in serums and livers.

These conclusions support the hypothesis that the enzymatic variations observed are not limited to human virus hepatitis (*9*). Furthermore, the necrosis of hepatic cells seems to play an important role in the pathogenesis of the phenomenon (passage from the liver to the blood of enzymatic metabolites).

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Table 1. Transaminase activities at 37°C of livers and serums of mice. Aspartic-ketoglutaric transaminase activity is measured in micromoles of oxalacetate formed, and alanine-ketoglutaric transaminase activity is measured in micromoles of pyruvate formed.

Item	Normal mice	Infected mice	± %	Student's *t*
*Liver**				
Oxalacetate	115.1	86.6	− 25	4.31†
Pyruvate	111.6	58.8	− 48	5.93†
As-K/Al-K	1.03	1.46	+ 41	3.70†
Serums‡				
Oxalacetate	2.98	31.7	+ 999	3.98§
Pyruvate	0.95	37.7	+3867	4.44§
As-K/Al-K	3.04	0.84	− 75	4.42§

* Averages of 15, 100 mg of tissue for 10 minutes. † *t* significant > 2.763 ($P = 0.01$), $G = 28$. ‡ Averages of five pools, each from three of the same mice, 1 ml for 15 minutes. § *t* significant > 3.355 ($P = 0.01$), $G = 8$.

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5 March 1956

Consistent Biochemical Pattern in Malignant Tumors

In a previous study (*1*), a variety of normal and malignant tissues were subjected to cell fractionation by differential centrifugation. In all of the malignant tissues studied, the apportionment of protein among the various cell fractions showed a remarkably consistent pattern in which the nuclear and final supernatant-fluid fractions contained most of the protein and in which the mitochondrial and microsome fractions contained relatively little. The original series included 15 fractionations of nine malignant animal tumors, but only two human tumors.

Recently it has become possible to extend the observations to four more malignant human tumors (*2*). These included a lymph node affected by Hodgkin's disease, an inguinal lymph node containing an epidermoid carcinoma metastatic from the penis, a fibrosarcoma superficial to the posterior costal margin, and a cer-

vical lymph node containing an epidermoid carcinoma of undetermined primary site. All of the specimens were chilled immediately after removal at surgery and were maintained below 3°C throughout the fractionation procedure (*1*).

It was found that the human tumors (Table 1) varied considerably in concentration of protein nitrogen and ribose nucleic acid (RNA) in each cell fraction when the concentrations were expressed as the amount per unit of desoxyribose nucleic acid (DNA) in an equivalent amount of the whole tissue (*3*). On the other hand, when the quantity of protein nitrogen, or RNA, in each cell fraction was expressed as a percentage of the total amount present in the tissue (Table 2), it became evident that all of these malignant human tumors showed a consistent pattern in the distribution of protein among the cell fractions. In all of these tumors, the nuclear and final supernatant-fluid fractions each contained approximately 40 percent of the protein, whereas the mitochondrial and microsome fractions each contained only about 10 percent of the protein. This pattern is the same as that found previously in the animal tumors (summarized in Table 2), which included three rat hepatomas induced by different carcinogens, three transplantable rat tumors (Jensen sarcoma, Flexner-Jobling carcinoma, and Walker-256 carcinosarcoma), and three transplantable mouse tumors (a mammary carcinoma, an adrenal carcinoma, and a lymphosarcoma).

Three distinct patterns were found in the distribution of protein among the cell fractions of the normal tissues studied previously (Table 2). The first pattern, that of the thymus and possibly the adrenal, was similar to that of the tumors, with the bulk of the protein in the nuclear and supernatant-fluid fractions and relatively little in the mitochondria and microsome fractions. The second pattern, which is characteristic of liver and kidney, differed from that of the thymus and tumors by having a relatively large portion of the protein in the mitochondrial fraction. The pancreas and submaxillary gland provided the third pattern, which differed from that of the thymus and tumors by the presence of a relatively large portion of the protein in the microsome fraction. It seems probable that the distribution of protein found in the thymus and tumors represents the complement of cell components normally present in relatively unspecialized tissues, and that the large quantity of mitochondria in liver and kidney, as well as the large quantity of microsomes in pancreas and submaxillary gland, reflects the development of additional equipment required for the special functions of these tissues. These interpretations are consistent with the recognized importance of the mitochondria in the production of energy for the cell, in carbohydrate and lipid metabolism, and in esterification reactions (*4*). They are also consistent with the recent work that suggests a dominant role for the microsomes in the synthesis of protein (*5*).

Table 1. Concentration of protein-nitrogen and RNA in cell fractions from malignant human tumors.*

Tumor	Protein nitrogen†				Ribose nucleic acid†			
	Nuc	Mt	Micro	Super	Nuc	Mt	Micro	Super
Hypernephroma‡	2.76	0.49	0.74	1.89	0.62	0.12	0.21	0.30
Fibroscarcoma No. 1‡	1.75	0.32	0.46	1.31	0.50	0.14	0.28	0.37
Hodgkin's disease	0.50	0.17	0.18	0.49	0.04	0.03	0.11	0.09
Epidermoid carcinoma No. 1	0.88	0.21	0.21	0.69	0.25	0.11	0.20	0.23
Fibrosarcoma No. 2	2.26	0.76	0.27	2.10	§	§	§	§
Epidermoid carcinoma No. 2	0.89	0.07	0.16	0.64	0.17	0.02	0.14	0.26

* Expressed as milligrams of protein-nitrogen or RNA in a given tissue fraction per milligram of DNA in an equivalent amount of whole tissue (*2*).
† Nuc, nuclear fraction; M, mitochondria; Micro, microsomes, Super, supernatant fluid.
‡ From previous study (*1*).
§ Ribose nucleic acid samples accidentally lost during processing.

Table 2. Percentage distribution of protein and RNA among cell fractions of various normal and malignant tissues.*

Tissue	Protein nitrogen†				Ribose nucleic acid†			
	Nuc	Mt	Micro	Super	Nuc	Mt	Micro	Super
Human tumors								
Hypernephroma	47	8	13	32	50	10	17	24
Fibrosarcoma No. 1	46	8	12	34	39	11	22	29
Hodgkin's disease	37	13	13	37	15	11	41	33
Epidermoid carcinoma No. 1	44	11	11	35	32	14	25	29
Fibrosarcoma No. 2	42	14	5	39				
Epidermoid carcinoma No. 2	51	4	9	36	29	4	24	44
Animal tumors‡	38 ± 5	8 ± 3	13 ± 2	40 ± 3	32 ± 9	10 ± 3	29 ± 5	30 ± 5
Normal tissues§								
Thymus, rat	58, 60	3, 3	8, 7	32, 32	0, 15	3, 3	37, 30	61, 51
Adrenal, human	20	13	17	51	16	9	37	37
Liver, rat	14, 17	34, 30	19, 17	32, 36	10, 12	28, 27	47, 41	15, 20
Liver, mouse	21	32	11	37	11	39	29	21
Kidney, rat	16, 17	26, 27	17, 16	40, 40	14, 15	13, 17	32, 31	40, 37
Pancreas, rat	14, 16	8, 9	32, 34	46, 40	4, 6	2, 2	51, 55	42, 37
Salivary gland, rat	11, 29	8, 8	29, 27	52, 36	9, 23	3, 3	54, 48	35, 25

* The quantity of protein nitrogen or RNA in each cell fraction is expressed as a percentage of the total protein nitrogen or RNA present in the tissue.
† Nuc, nuclear fraction; Mt, mitochondria; Micro, microsome; Super, supernatant fluid.
‡ Average values, ± mean deviation, obtained in 15 fractionations of nine different animal tumors, calculated from individual values previously reported (*1*).
§ Where two values are given, they were obtained from two different experiments.

Although the distribution of protein within the tumor cells was similar to that in the thymus, the tumor cells differed from these, and from all the other cells studied so far, in the high proportion of RNA in the nuclear fraction (Table 2).

Many previous studies have shown that, for a wide variety of biochemical properties, malignant tumors show a narrower range of values than do normal tissues (*6*), but the data presented here appear to offer the first demonstration of a consistent biochemical pattern in malignant tumors among at least four variables—namely, the proportion of cell protein to be found within each of the four cell fractions. This pattern was found without exception in the cells of a wide variety of malignant tumors, including primary and metastatic human tumors, induced and transplanted animal tumors, carcinomas as well as sarcomas, in three different animal species. In all of the tumors studied, the nuclear and final supernatant-fluid fractions each contained approximately 40 percent of the protein, and the mitochondria and microsome fractions each contained about 10 percent of the protein. In most of the tumors studied, the nuclear fraction contained 30 percent or more of the RNA. This was considerably more than the amount found in the nuclear fraction of any of the normal tissues studied.

Thus, while malignant tumors show manifold differences in their histologic

appearance (differences which provide the basis for clinical diagnosis), and although they show subtle differences in many biochemical properties, the consistent pattern demonstrated here in the distribution of protein among the various parts of the cell indicates that, within their cells, all of the tumors studied possess the same basic architecture.

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19 December 1955

Antiserotonins in Hypertension and the Antimetabolite Approach to Chemotherapy

In 1944, as a result of experiments with antimetabolites of vitamins and purines, Woolley (*1*) suggested that useful pharmacological agents could be made which would control specific noninfectious diseases. This could be accomplished by use of the antimetabolite idea coupled with knowledge of vitamin or hormone deficiencies. Thus, a disease arising from an excess of one of the hormones present in an animal might logically be controlled by production of a structural analog of this hormone that would act antagonistically to it. This idea was an extension of that of Woods (*2*) and Fildes (*3*) regarding the mechanism of control of bacterial infections by sulfanilamide.

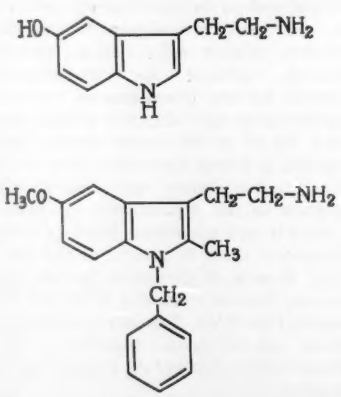

Fig. 1. Structures of serotonin (top) and 1-benzyl-2,5,dimethyl-serotonin or BAS.

The prospect that was thus raised of a rational chemotherapy of both noninfectious and infectious disorders through the use of antimetabolites has, in the intervening years, been viewed with considerable skepticism by many investigators. These have reminded us that penicillin and other wondrous agents have not been discovered in this fashion but rather have been found empirically—for example, by screening programs. Because this opposing view has enjoyed such acceptance, we would like to record the following facts as an interesting case in which the antimetabolite approach has led to the development of a new series of pharmacological agents capable of checking a common human disease.

In 1952 we (*4*) suggested that essential hypertension might arise from an excess of serotonin. We also saw that if this were so, the disease might be controlled with a suitable antimetabolite of serotonin. The first antiserotonins were thus envisioned and produced. We have pursued this idea and have made a member of this series of antiserotonins which is apparently suitable.

The compound in question is 1-benzyl-2,5-dimethyl serotonin, a benzyl analog of serotonin, or BAS. The structures of BAS and of serotonin are shown in Fig. 1. This antimetabolite was synthesized in the manner described previously (*5, 6*) and was found to be highly effective by the oral route in protecting dogs from the pressor action of serotonin (*6, 7*). However, it was not merely a hypotensive agent, because, in normal dogs and in one normotensive human being, it did not lower blood pressure significantly. What it did do was to protect these animals against the pressor effects of injected serotonin.

As a result of these findings, the aid of Robert Wilkins of the Massachusetts Memorial Hospital was sought in order that a clinical trial of this antimetabolite could be made. Preliminary findings reported by Hollander, Michelson, and Wilkins (*8*) have shown that BAS will bring about reduction in blood pressure of patients with hypertension. Only small doses were needed, and these did not seem to cause harmful side-effects.

Several problems arose during the discovery of BAS, and some are worthy of comment here. (i) It was realized at the outset that a drug, to be useful in this disease, must be orally effective. (ii) The drug should also have a low inhibition index, and it should be an irreversible antagonist of serotonin (*9*). This was desirable so that the serotonin that is constantly being produced in the body would not readily nullify the effects of the drug. (iii). The compound must not affect the central nervous system so as to cause mental disturbances. This was a very real problem, because early in the investigation of antiserotonins we had found (*10*) that some of them do disturb the mind. It was therefore necessary to design one that would not elicit this kind of effect.

The antiserotonin, BAS, was so designed that it met these requirements. For example, the benzyl group was introduced to help with points i and ii. The validity of this can be seen from the fact that the corresponding debenzylated compound was shown to lack the high activity by the oral route and to lack some of the irreversible character (*7*). The primary aliphatic amino group was retained in the molecule to deal with point iii. Several compounds with the amino group either attached at other points or otherwise modified caused profound behavioral changes in animals (*10*).

The findings of Wilkins and his collaborators (*8*) show that a suitably constructed antimetabolite of serotonin such as BAS can bring about a reduction in the blood pressure of many hypertensive patients and can do this without causing obvious harmful side-effects. Whether or not such a compound will be a useful drug remains to be seen. It is quite probable that further alteration of the structure of serotonin to give other members of this series of antimetabolites will be needed in order to achieve the best agent. Nevertheless, present facts indicate that the original hypotheses are worthy of attention. These hypotheses are (i) that a new series of drugs may be discovered with the antimetabolite idea, and (ii) that serotonin may be causally related to essential hypertension.

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27 February 1956

Book Reviews

Physics of Fully Ionized Gases. Lyman Spitzer, Jr. Interscience, New York, 1956. 105 pp. Cloth, $3.50; paper, $1.75.

The growing importance of the knowledge of the behavior of fully ionized gas plasmas, both in astronomy and in physics, indicates an urgent need for a convenient comprehensive summary of the basic characteristics of such plasmas. Existing analyses of the basic theory are largely scattered through an extensive, dispersed literature in the form of original papers serving interests ranging from those of the astrophysicist to the experimental physicist working on high-temperature arcs, intense shock waves, and glow discharges.

Lyman Spitzer, who has been actively interested in plasma properties and has been one of the major contributors to the field, has collected the basic mathematical theory of the plasma in a concise little treatise for the use of graduate student and investigator alike. The subject matter is well chosen and restricted to the properties that are essential to an understanding of the subject. Where observational data are readily adapted to confirm the theoretical deductions, they are indicated. However, no attempt is made to give a detailed comparison between theory and experiment. The applications and significance of the relationships derived are, however, indicated along the way.

This book is written for those who have had an introductory course in theoretical physics and for those who have a knowledge of Maxwell's equations and a working knowledge of the vector analysis.

The contents cover five chapters: "Motion of a particle" (equations of motion, particle drifts, magnetic moment, and acceleration of particles); "Macroscopic motion, principles" (electric neutrality, basic equations, steady-state solutions, and relationships between microscopic and macroscopic velocities); "Macroscopic motion, problems" (electric currents, motion of material across lines of force, and pinch effect); "Waves in a plasma" (electromagnetic waves, hydromagnetic waves, electrostatic waves); and "Encounters between charged particles" (distant encounters, diffusion coefficients, relaxation times, electric resistivity, thermal conductivity, and radiation).

This book is up to date, and the literature coverage is adequately complete. It is extremely clear, concise, and well written. It is an excellent and welcome addition to the literature in the general field of gaseous electronics and will be useful to astronomer, physicist, and engineer alike.

LEONARD B. LOEB
Department of Physics,
University of California, Berkeley

Advances in Genetics. vol. VII. M. Demerec, Ed. Academic Press, New York. 1955. ix + 309 pp. Illus. $8.

This latest in a series of annual monographs on genetics contains six chapters, an index of this volume, and, of special value, a cumulative index of the preceding six volumes. A study of the cumulative index yields a broader perspective of the diverse phenomena and of the multiplicity of organisms used in studies of genetics than the study of any one volume alone. The fruit fly *Drosophila* is still a favorite organism for genetic studies, although its position is being rivaled by certain microorganisms, Lepidoptera, corn, cotton, mice, and man. The studies involve physiological, population, and cytogenetics as well as many aspects of formal genetics, including linkage and recombination.

In the present volume, the first chapter on "Microbial drug resistance," by Vernon Bryson and Waclaw Szybalski, is an incisive discussion of the origin of drug resistance, pointing out that induced resistance may be either genetic or nongenetic and that critical evidence must be adduced if one is to discriminate between the genetic and nongenetic origins. In the second chapter on "The 'obscura group' of the genus *Drosophila*," Adriano A. Buzzati-Traverso and Renzo E. Scossiroli bring together the wealth of data on this group to offer a unified picture of the phylogeny and distribution of the American and Eurasian members.

The role of chromosomal inversions in tying together adaptive gene combinations is thoroughly reviewed in the next chapter on "Chromosomal polymorphism in the Diptera," by A. Brito da Cunha. By means of hybridization and several experimental techniques, an astonishing variety of nuclear-cytoplasmic combinations is possible in Amphibia. The contributions of studies of these combinations to embryology and to some extent to the interpretation of evolution are discussed by John A. Moore in the fourth chapter on "Abnormal combinations of nuclear and cytoplasmic systems in frogs and toads."

The fifth chapter on "Recent genetics of the domestic rabbit," by Paul B. Sawin, is an exhaustive survey of the 100 or more studies on the genetics and physiology of the rabbit in recent years. There are 38 named loci, and 16 of these are distributed in six genetic linkage groups. In addition, a large number of loci are known to affect the variability in numerous quantitative characters. The final chapter, by Ryuhei Takahashi, is on "The origin and evolution of cultivated barley." Since barley enjoys a position as an important food crop and has probably been even more important in the remote past, an unraveling of the problem of its origin will be of interest to geneticists, agronomists, archeologists, and anthropologists. The question cannot be finally settled at this point, because several alternative hypotheses are admissible.

EARL L. GREEN
Institute of Genetics,
Ohio State University

Resonance in Organic Chemistry. George Willard Wheland. Wiley, New York; Chapman & Hall, London, 1955. xiii + 846 pp. Illus. $15.

George Wheland candidly presents in this book an unvarnished picture of the sad state of affairs that exists regarding attempts to treat quantitatively from first principles the forces that hold together even slightly complicated molecules. At the same time he imaginatively explores the firm, qualitative successes of the application of the theory of resonance to molecular structure and reactivity in organic compounds. His treatment refreshingly avoids any tendency toward oversimplification and reflects an outstanding command of the material.

Readers who are familiar with his earlier efforts to translate quantum mathematics into the symbolism of organic chemistry will be pleased to find that the new work contains sections on spectroscopy and systems in transit, omitted from the earlier works. Some may object to the somewhat limited treatment afforded portions of these subjects, but their objections should be tempered by

the author's necessary circumscription of the area to be mapped and his scrupulous attention to the clarification of detail in what is discussed. The specific failures to broaden the section on spectroscopy to include the infrared and the useful empirical relationships in the ultraviolet, as well as that on reactivity to include carbonyl addition reactions, may be noted. In this regard the work cannot serve completely to introduce the student of theoretical organic chemistry to his subject.

The valence-bond approach is used almost exclusively—a decision of the author that will certainly be welcomed by the majority of organic chemists who have found the resonance hybrid symbolism more convenient to their understanding. One questions, somewhat, the insistence that the difficulties of the valence-bond theory are so evenly matched by those of the molecular orbital approach to structure. The latter seems clearly ahead in comprehensibility to an organic chemist where electronic transitions are involved and, given time, may provide a clearer notion of molecular structure.

All will welcome the substantial appendixes; one provides a thorough grounding in the mathematical basis for the theory of resonance, and the other represents an extensive collection of data on bond lengths and angles.

RICHARD H. EASTMAN
Stanford University

Problems in Amoebiasis. Charles W. Rees. Thomas, Springfield, Ill., 1955. x + 119 pp. Illus.

After devoting a lifetime of investigation to the subject of amebiasis, Charles Rees has written a small, compact book on the problems that might be encountered today by one interested in studying *Endamoeba histolytica*. This book, although admirably brief (100 pages), covers various aspects of amebiasis quite adequately.

Although the author has been more closely associated with basic investigations, the review of the clinical question is more complete with respect to such topics as diagnostic procedures, chemotherapy, pathology, and so forth.

The reason for a less detailed account of the fundamental biological and physiological properties of *E. histolytica* is well presented by the author. Although the protozoan has been successfully cultured for approximately 30 years under a variety of conditions, the apparent dependency for growth of the ameba on the presence of other living cells, either bacteria, protozoans, or animal cells, has greatly hindered basic studies of the organism.

Therefore, quite a respectable amount of knowledge is presented on the culture of the ameba—albeit in association with other organisms—and this contrasts quite sharply with the paucity of information on the physiology of the ameba. Rees, with his considerable experience in cultivating *E. histolytica*, on the subject of culture, has deviated from the review form to present selectively some of his own work in greater detail. This is justified on the basis of practical aids included to help obtain monaxenic cultures. It is not justified, perhaps, in the case of his own physiological experiments which he has included. There is a fairly complete bibliography at the end of each topic.

NATHAN ENTNER
Department of Preventive Medicine, New York University College of Medicine

Recent Studies in Avian Biology. Albert Wolfson, Ed. Published under the sponsorship of the American Ornithologists' Union. University of Illinois Press, Urbana, Ill., 1955. 479 pp. Illus. $7.50.

This volume was prepared at the request of a committee of the American Ornithologists' Union for a book that would present recent research in ornithology. The editor states in the preface that the book has two objectives ". . . to stimulate further research in ornithology" and "to provide . . . a convenient and authoritative source of the contributions of ornithological research to broader biological fields." Although the book falls somewhat short of these objectives in its over-all presentation, certain of the chapters are very well written and should stimulate interest. Part of the difficulty of the book is that there were 13 different contributors, and the chapters were received for publication at various times from January 1952 to April 1955. There is a considerable difference, therefore, in the recency of bibliographic references.

The book is divisible roughly into three phases: systematics, including paleontology (three chapters); anatomy, physiology, behavior, migration, and diseases (eight chapters); and population studies (two chapters). The first chapter, "Avian Systematics" (Alden H. Miller) should be of considerable interest to all biologists. The author gives an excellent summary of the advantages and disadvantages of bird study in relation to the broad problems of taxonomy and evolution. He emphasizes that avian taxonomy suffers from inadequate collections and inadequate genetic studies and that, in common with some other fields of taxonomy, there is a tendency to overemphasize minor differences of racial character. The author is an advocate of the importance of geographic isolation in avian evolution. Biologists should also find much of value in the chapter on "Recent Revisions in Classification" (Herbert Friedman) and on "Paleontology" (Alexander Wetmore).

The chapter on "Anatomy" (Harvey I. Fisher) is especially impressive because of the suggestions of anatomical problems that remain to be solved. The chapters on "Bird Navigation" (Donald R. Griffin), "Migration" (Donald S. Farner), "Nocturnal Migration" (George H. Lowery, Jr., and Robert J. Newman), and "Breeding Biology" (David E. Davis) are interestingly written and well documented. These chapters will be valuable because of their excellent bibliographies.

The physiology of birds receives very modest treatment in this book. It is true that much of the recent avian physiology has centered about domestic forms and that data for wild birds are relatively scarce. It was a disappointment, however, to discover that the discussion of endocrine glands is concerned primarily with their relation to migration and that hormones per se are considered only in relation to sex differentiation. The latter chapter (L. V. Domm), although it was the most recent to be received for publication, has the least complete bibliography.

The chapters on "Population Research" (Joseph J. Hickey) and "Bird Banding" (Donald S. Farner) are interesting and have elaborate bibliographies. These should be particularly valuable to other biologists. The final chapter on "Diseases of Birds" (Carlton M. Herman) is also well documented; but, as the author points out, this subject has been sadly neglected except for poultry diseases.

There is much to commend this book and any lack in unified presentation is probably compensated for by the excellence of bibliography.

WILLIAM R. BRENEMAN
Department of Zoology and Waterman Institute, Indiana University

The Chemistry of Tanning Processes. K. H. Gustavson. Academic, New York, 1956. 403 pp. Illus. $9.

This is a book on the fundamental chemistry of tanning. Besides extensive coverage of chrome and vegetable tanning, which are the two most important tannages, the author has included chapters on Syntans, aldehydes, and quinone

and oil. In addition, a chapter on combination tannages is included, which is the first of its type in any English textbook on tanning. A survey of chemical combinations similar to those in tanning that are of biological and medical importance is included to show that many reactions similar to those in tanning occur in natural processes.

The author is one of the foremost world authorities on tanning, especially chrome tanning, and much of the material given in the book is based on his own work. In the first four chapters, which discuss the theories of chrome tanning, he has referred to his own work in 102 out of 240 literature citations. In addition, he has an excellent knowledge of the world literature on leather chemistry. For this reason, the book contains much of the valuable work done in Germany on synthetic tanning materials. The chapter on Syntans is probably the best to appear in any book on leather in the English language.

The ideas and theoretical conclusions of the author himself predominate throughout. This is, of course, as would be expected, and, although he does an excellent job in interpreting highly complicated mechanisms of reaction, the reader would feel more convinced if more data were presented to support some of the conclusions. The imagination and fertile mind of the author are, however, inspiring, and the ideas presented will undoubtedly serve as the foundation for further investigations by research men.

This book gives an up-to-date coverage of the literature, and the fundamental chemistry of the tanning reactions is interpreted according to the most modern concepts of the behavior of high polymeric compounds. It should be helpful to everyone who is engaged in the tanning industry and, in my opinion, is a necessary addition to the library of all leather research chemists.

JOSEPH R. KANAGY

Leather Section,
National Bureau of Standards

Protoplasmatologia. Handbuch der Protoplasmaforschung. vol. X, *Red Cell Structure and Its Breakdown.* Eric Ponder. Springer, Vienna, 1955. 123 pp. Illus. $9.50.

Since the publication of the author's monograph *Hemolysis and Related Phenomena* (1948) new observations and techniques have become available which necessitate a different approach to the problems of the red cell and its breakdown. This volume is concerned with all except the last of the following new departures: the observation of fine structure, made with the electron microscope; the realization that there are many varieties of ghosts that have properties of their own; the increasing amount of evidence that some of the simplifying hypotheses regarding the osmotic behavior of the red cell have broken down; the observation of the hitherto neglected fragmentation phenomena; the realization that many lytic reactions cannot be described by the equations for simple chemical reactions; and, finally, the appreciation of the fact that the mammalian red cell has a complex metabolism and that this metabolism is concerned with processes such as active ion transport.

The author divides the very complex subject matter into sections entitled: "The structure of the mammalian red cell"; "Osmotic hemolysis"; "The kinetics of hemolysis"; "Fragmentation, erythrophagocytosis, and the effects of tissue lysins." These are generously illustrated with 58 figures, including graphs, diagrams, and microphotographs as obtained with various instruments, especially the electron microscope. The result is a readable account of especial value to students of general physiology. The use of mathematical language and arguments is in the main restricted to section 3 on kinetics of hemolysis. Another restriction concerns the material, inasmuch as red cell destruction is dealt with from the point of view of the cell rather than from the point of view of the organism. The bibliography has 210 full citations, principally of work done within the last 10 years, but often including one key reference to serve as guide to work done earlier.

ROBERT BLOCH

Biological Abstracts,
University of Pennsylvania

New Books

The Chemical Process Industries. R. Norris Shreve. McGraw-Hill, New York, ed. 2, 1956. 1004 pp. $11.50.

Spring on an Arctice Island. Katharine Scherman. Little, Brown, Boston, 1956. 331 pp. $5.

Enzymes: Units of Biological Structure and Function. Henry Ford Hospital International Symposium. Oliver H. Gaebler, Ed. Academic Press, New York, 1956. 624 pp. $12.

Fundamentals of Vibration Analysis. N. O. Myklestad. McGraw-Hill, New York, 1956. 260 pp. $6.50.

E. A. Birge, a Memoir. G. C. Sellery. With an appraisal of Birge by C. H. Mortimer. University of Wisconsin Press, Madison, 1956. 221 pp. $3.50.

Understanding Human Behavior. James L. McCartney. Vantage Press, New York, 1956. 258 pp. $3.50.

College Chemistry. Andrew J. Scarlett. Holt, New York, 1956. 499 pp. $5.50.

General Zoology. David F. Miller and James G. Haub. Holt, New York, 1956. 550 pp. $6.95.

General Biology. Willis. H. Johnson, Richard A. Laubengayer, Louis E. DeLanney. Holt, New York, 1956. 618 pp. $6.50.

The Human Body, Its Anatomy and Physiology. C. H. Best and N. B. Taylor. Holt, New York, ed. 3, 1956. 723 pp. $6.75.

Tombs, Temples and Ancient Art. Joseph Lindon Smith. Corinna Lindon Smith, Ed. University of Oklahoma, Norman, 1956. 349 pp. $5.

Man, Culture, and Society. Harry L. Shapiro, Ed. Oxford University Press, New York, 1956. 380 pp. $7.50.

Histologie und Mikroskopische Anatomie des Menschen. W. Bargmann. Thieme, Stuttgart, Germany, rev. ed. 2, 1956 (order from Intercontinental Medical Book, New York 16). 796 pp. $16.55.

Arctic Wilderness. Robert Marshall. George Marshall, Ed. University of California Press, Berkeley, 1956. 171 pp. $3.75.

What Flowering Tree Is That? Edwin A. Menninger, The Author, Stuart, Fla. 110 pp. $3.

Proceedings of the International Conference on the Peaceful Uses of Atomic Energy. vol. 1. *The World's Requirements for Energy: The Role of Nuclear Energy,* 479 pp.; $8. vol. 4, *Cross Sections Important to Reactor Designs;* 357 pp.; $7.50. vol. 5, *Physics of Reactor Design;* 545 pp.; $9. vol. 6, *Geology of Uranium and Thorium;* 825 pp.; $10. vol. 7, *Nuclear Chemistry and Effects of Irradiation;* 691 pp.; $10. vol. 8, *Production Technology of the Materials Used for Nuclear Energy;* 627 pp.; $10. vol. 9, *Reactor Technology and Chemical Processing;* 771 pp.; $10. vol. 10, *Radioactive Isotopes and Nuclear Radiation in Medicine;* 544 pp.; $8. vol. 11, *Biological Effects of Radiation;* 402 pp.; $8. vol. 12, *Radioactive Isotopes and Ionizing Radiations in Agriculture, Physiology, and Biochemistry;* 553 pp.; $9. vol. 13, *Legal, Administrative, Health and Safety Aspects of Large-Scale Use of Nuclear Energy;* 393 pp.; $7. United Nations, New York, 1956.

Precision Electrical Measurements. Proceedings of an international symposium on precision electrical measurements held at the National Physical Laboratory 17–20 Nov. 1954. Philosophical Library, New York, 1956. $12.

Proceedings of the Third International Congress of Biochemistry. Brussels 1955. Claude Liébecq, Ed. Academic Press, New York, 1956. 544 pp. $15.

Operations Research for Management. vol. II. Joseph F. McCloskey and John M. Coppinger, Eds. Johns Hopkins Press, Baltimore, 1956. 563 pp. $8.

Introductory Organic Chemistry. With certain chapters of biochemistry. E. Wertheim and Harold Jeskey. McGraw-Hill, New York, ed. 3, 1956. 476 pp. $5.50.

Electromagnetically Enriched Isotopes and Mass Spectrometry. Proceedings of the conference held in Cockcroft Hall, Harwell, England, 13–16 Sept. 1955. M. L. Smith, Ed. Academic Press, New York; Butterworths, London, 1956. 272 pp. $8.

Meetings and Societies

STIP Boulder Conference

Eight counselors and four center coordinators from the Centers for the Study on the Use of Science Counselors, a major activity of STIP, met on the campus of the University of Colorado in Boulder, 19–23 June. They heard lecturers on modern developments in biology, chemistry, physics, and mathematics, and on aptitude testing, supervision of secondary-school science programs, and evaluation. The program included reports on counseling programs in Indiana and Texas. There were special work sessions on such topics as overview of problems in science and mathematics teaching, materials and class activities in science and mathematics, and the job of the counselor.

Lecturers in science from the University of Colorado staff included Wesley E. Brittin (physics), Burton W. Jones (mathematics), Harold F. Walton (chemistry), and David Hawkins (philosophy). Ralph W. Lefler (Purdue University and Archie MacLean Owen (science supervisor in Los Angeles public schools), representing science, and John A. Brown (University of Wisconsin), and Elizabeth Roudebush (mathematics supervisor in the Seattle public schools), representing mathematics, were on the conference staff. B. L. Dodds (University of Illinois), a member of the advisory board for the study, addressed the conference on the subject, "Science education and current trends in the secondary-school curriculum." Dodds also worked with the conference staff in the development of a plan of evaluation for the study and in determining plans and procedures for operation of the centers.

The four centers for the study [*Science* **123**, 624 (13 Apr. 1956)] are the University of Nebraska, University of Oregon, Pennsylvania State University, and University of Texas. Arrangements with the public schools to participate in the study have been made by the centers. Center coordinators are James A. Rutledge (Nebraska), Edward Ebbighausen (Oregon), T. R. Porter (Pennsylvania), and Wayne Taylor (Texas). Each center will be operated with the cooperation of the state department of education in the state, and the science counselors will, in many instances, travel with supervisors from the state departments.

This is a study planned to test a method of (i) upgrading the science and mathematics instruction in secondary schools through the use of teacher-counselors; (ii) providing in-service aid to teachers of science and mathematics, with stress on the most recent developments, improved laboratory and demonstration techniques, and good teaching methods; (iii) bringing university staff members in science, mathematics, and education into closer working relationships on a problem of common concern; (iv) bringing university science staffs into closer touch with secondary schools; (v) providing direct service by universities to secondary schools; (vi) providing a means of increasing cooperation between staff members in universities and state departments of education.

Grants to the four centers have been made for the academic year 1956–57. Under these grants, each center has employed for 1 year two teachers of science and/or mathematics to serve as counselors to science and mathematics teachers in secondary schools in the region of the university. It is expected that the study will be continued for a second year. Pamphlets describing the study will be available from the AAAS office after 1 Aug.

JOHN R. MAYOR
AAAS, Washington, D.C.

Meeting Notes

■ The eastern summer meeting of the American Physical Society was held 21–23 June at Yale University. William W. Watson, chairman of the university's physics department, acted as host for the conference, which was attended by some 400 physicists. More than 140 scientific papers were contributed as well as approximately 20 invited papers. The society's meeting in New Haven was its first at Yale since 1932.

The conference banquet was addressed by Louis W. McKeehan, professor emeritus of physics at Yale, and Ernest C. Pollard, Yale professor of biophysics. Among the major speakers were W. G. Shepherd of the University of Minnesota; G. R. Brewer of the Hughes Aircraft Company; Howard Reiss and W. L. Brown of the Bell Telephone Laboratories; E. R. Beringer, Richard B. Setlow, Vernon Hughes, and Howard L. Schultz of Yale; N. F. Ramsey of Harvard; B. J. Bray of Brown; E. W. Mueller of Pennsylvania State University; F. J. Norton of the General Electric Company; G. A. Anslow of Smith College; L. M. Branscomb of the National Bureau of Standards; S. C. Brown of Massachusetts Institute of Technology; and T. J. Carroll of the Lincoln Laboratory. In addition, J. S. Foster of McGill University spoke on Canadian research and on results of a visit to the Soviet Union.

■ The fall meeting of the Society for the Scientific Study of Religion will be held at Harvard University on 10 Nov. The general subject is expected to be "Anthropology and Religion." Social scientists who have papers to propose on this or related subjects are invited to send three copies of 300 word abstracts to Ralph W. Burhoe, American Academy of Arts and Sciences, Cambridge 36, Mass., *before 30 Sept.*

Society Elections

■ American Nuclear Society: pres., C. Rogers McCullough, Monsanto Chemical Company; v. pres., Jerome D. Luntz, editor of *Nucleonics*; treas., Karl Cohen, General Electric Company; exec. sec., W. W. Grigorieff, Oak Ridge Institute of Nuclear Studies.

■ Massachusetts Society for Research in Psychiatry: pres., Max Rinkel; v. pres., Philip Solomon; sec.-treas., Peter H. Knapp.

■ American Society of Biological Chemists: pres., H. E. Carter, University of Illinois; pres.-elect, John T. Edsall, Harvard University; sec., Philip Handler, Duke University; treas., Stanford Moore, Rockefeller Institute. Representatives to the AAAS Council are A. E. Wilhelmi and Karl Folkers.

Forthcoming Events

August

6–7. International Mathematical Symposium on Algebraic Topology and Its Applications, Mexico City, Mexico. (Miss J. Silva, Instituto de Matemáticas, Torre de Ciencias, Ciudad Universitaria, México 20, D.F.)

6–8. Soc. of Automotive Engineers, national West Coast meeting, San Francisco, Calif. (Meetings Div., SAE, 29 W. 39 St., New York 18.)

6–10. Poultry Science Assoc., annual, Raleigh, N.C. (C. B. Ryan, Dept. of

Kodak reports to laboratories on:

the genial chief control chemist across the road . . . how to make alignment decisions that don't take so much out of a man

That man

The building on the left houses our control lab, the building on the right some production labs.

The large drum in the cart contains o-iodobenzoic acid. This started out as *Anthranilic Acid* (Eastman 29, 2-$NH_2C_6H_4COOH$). The production man had diazotized it, sandmeyered the diazonium group to an iodine, esterified the crude colored product with methanol, distilled the ester, hydrolyzed the colorless distillate back to the acid by treatment with alkali, neutralized the alkali with mineral acid, washed the precipitated product, dried it, and sent it across the road.

First thing the genial chief control chemist noticed when he got to this item was that it melted cloudy. The g.c.c.c. is a bear about cloudy MP's. This time his suspicions were confirmed. An acetone solution of the material is also a little cloudy. Obviously, something polar is present that shouldn't be. Back across the road the o-iodobenzoic acid is going, for removal of the trace of occluded salt that prevents the affixing of the white label reading *o-Iodobenzoic Acid* (Eastman 572).

The other drum contains 4-nitro-o-phenylenediamine. In a recent advertisement we offered an abstract of its use for the determination of α-keto acids in blood and urine. A grateful public showered us with orders. This is the first lot in years made to fill an actual demand, which is better than a potential one. And here it is going back across the road, because that man thinks the MP is a mite low. Instead of blaming the calibration of his thermometer, he suddenly decided to see if the material gives a perfectly clear solution in 0.5N hydrochloric acid. It doesn't, so there it is on the cart. (More than a week the customers had to be stacked up while the stuff was being cleaned up. When last asked, the g.c.c.c. was positively enthusiastic about the quality of *4-Nitro-o-phenylenediamine* (Eastman 4323).)

That is what you pay for when you buy Eastman Organic Chemicals. Part anyway. And there are some 3500 of them, ready and waiting. Distillation Products Industries, Eastman Organic Chemicals Department, Rochester 3, N. Y. (Division of Eastman Kodak Company).

No knots

Take the Great Pyramid of Cheops at Gizeh. Take the Eiffel Tower. Take the *Nautilus*. Take one of those gigantic atom smashers. Take even a little thing like a million dollar turbine in a power generating station or a 70-foot planer bed. Always there comes a moment when the engineer-in-charge has to say, "OK, boys. She'll never be lined up any better than she is right now. Let's get on with the job." And the irrevocable next step is taken. Making a decision like that can take a lot out of a man.

Any gadget that puts such a decision on firmer ground ought to be worth quite a bit in peace of mind alone, to say nothing of the time cards of all those men standing around waiting, waiting for the word.

Right here we could make a big mistake by overplaying our hand. Let's better make plain where the new *Kodak Axicon* stands in relation to the art of aligning long axes.

The word "axicon" was coined by one of our chaps to designate a simple new class of axially symmetric optical elements, which, with the study of optics a couple of millenia old, he was lucky and smart enough to invent. An axicon images a point source of light along the axis as a straight line in space. No wire, however tight, can be so perfectly free of kink and sag. What of a telescope, you say?

A telescope objective forms its image at a different little knot in space for each successive target along the line of sight. In following these images with the cross hairs, there is a chance for error of parallelism between the focusing motion and the axis. There is also doubt about how much of the observed displacement is real and how much of it is parallax because of inability to locate the knots exactly. With an

No, it's not a lens. It's not curved in a plane containing the axis of symmetry.

axicon there is no focusing. Anywhere along a length of 40 feet—100 feet or more, if you like—the line of light is equally thin, forms an equally hard little point of light where intercepted.

A procedure for aligning lower turbine shells with a Kodak Axicon Aligner *has been worked out in full detail and even timed. The friends with whom we worked out this procedure certainly know the turbine trade as well as anybody alive. That they, with all their experience, like the axicon method encourages us to believe that the booklet prepared for their operating personnel might make interesting reading for others faced with awesome alignment problems. For a copy, write Eastman Kodak Company, Military and Special Products Sales, Rochester 4, N. Y.*

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TRADE MARK

Poultry Husbandry, Texas A & M College, College Station.)

9–18. International Geographical Cong., 18th, Rio de Janeiro, Brazil. (H. O'R. Sternberg, Centro de Pesquisas de Geografia do Brasil, Faculdade Nacional de Filosofia, Av. Presidente Antonio Carlos 40, Rio de Janeiro.)

10–11. Minnesota Acad. of Science, New London, Minn. (B. O. Krogstad, Univ. of Minnesota, Duluth 5B.)

12–17. World Federation for Mental Health, 9th annual, Berlin, Germany. (Secretariat, 19 Manchester St., London W.1, England.)

13–16. National Medical Assoc., 61st annual, New York, N.Y. (J. T. Givens, 1108 Church St., Norfolk 10, Va.)

15–22. Canadian Teachers' Federation, Fredericton, N.B., Canada. (G. G. Croskery, 444 MacLaren St., Ottawa, Ontario, Canada.)

16–21. Symposium on X-Ray Microscopy and Microradiography, Cambridge, England. (W. C. Nixon, Cavendish Lab., Cambridge.)

17–25. International Cong. of Entomology, 10th, Montreal, Canada. (J. A. Downes, Div. of Entomology, Science Service Bldg., Ottawa, Ont., Canada.)

19–23. International Cong. on Diseases of the Chest, 4th, Cologne, Germany. (Executive Offices, American College of Chest Physicians, 112 E. Chestnut St., Chicago 11, Ill.)

19–24. International Symposium on Combustion, 6th, New Haven, Conn. (Combustion Symposium Office, Mason Lab., Yale Univ., New Haven 11.)

20–21. Mathematical Assoc. of America, 37th summer, Seattle, Wash. (H. M. Gehman, Univ. of Buffalo, Buffalo 14, N.Y.)

20–21. National Telemetering Conf., Los Angeles, Calif. (R. E. Rawlins, Lockheed Aircraft Corp., Burbank, Calif.)

20–24. Conf. on Scientific and Technical Writing, Philadelphia, Pa. (H. F. Arader, Univ. of Pennsylvania, 3400 Walnut St., Philadelphia 4.)

20–24. Institute of Mathematical Statistics, Seattle, Wash. (G. E. Nicholson, Jr., Dept. of Statistics, Univ. of North Carolina, Chapel Hill.)

20–24. International Cong. of Physical Medicine, 2nd, Copenhagen, Denmark. (S. Clemmesen, Kommune-hospitalet, Copenhagen.)

20–25. American Mathematical Soc., 61st summer, Seattle, Wash. (J. H. Curtiss, AMS, 80 Waterman St., Providence 6, R.I.)

21–24. Western Electronic Show and Convention, Los Angeles, Calif. (B. Angwin, General Electric Co., 11840 W. Olympic Blvd., Los Angeles 64.)

22–29. World Cong. of Sociology, 3rd, Amsterdam, Netherlands. (T. B. Bottomore, Skepper House, 13 Endsleigh St., London, W.C.1, England.)

24–28. American Astronomical Soc., joint with Astronomical Soc. of the Pacific, Berkeley, Calif. (J. A. Hynek, Harvard College Observatory, Harvard Univ., Cambridge 38, Mass.)

26–1. International Soc. of Haematology, 6th cong., Boston, Mass. (ISH, New England Medical Center, Harrison Ave. at Bennet St., Boston 11.)

26–30. American Inst. of Biological Sciences, Storrs, Conn. (H. T. Cox, 2000 P St., NW, Washington 6.)

27–31. Biological Photographic Assoc., 26th annual, Rochester, N.Y. (BPA, c/o 343 State St., Rochester 4.)

27–31. Colloquium on Statistical Mechanics of Transport Processes, IUPAP, Brussels, Belgium. (I. Prigogine, 40 Avenue F. D. Roosevelt, Brussels.)

27–31. Infrared Spectroscopy Inst., 7th annual, Nashville, Tenn. (N. Fuson, Dept. of Physics, Fisk Univ., Nashville 8.)

28–2. Colloquium on Semiconductors and Phosphors, IUPAP, Garmisch-Partenkirchen, Germany. (H. Maier-Leibnitz, Walter-von-Dyck-Platz 1, Munich 2, Germany.)

29–5. British Assoc. for the Advancement of Science, annual, Sheffield, England. (Secretary, BAAS, Burlington House, Piccadilly, London, W.1., England.)

29–8. International Soc. of Soil Science, 6th cong., Paris. (F. A. Van Baren, ISSS, Royal Tropical Inst., Mauritskade 63, Amsterdam, Netherlands.)

30–5. American Psychological Assoc., Chicago, Ill. (F. H. Sanford, 1333 16 St., NW, Washington 6.)

30–5. Psychometric Soc., Chicago, Ill. (L. V. Jones, Dept. of Psychology, Univ. of Chicago, Chicago 37.)

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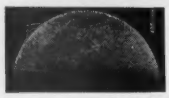

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1–9. International Cong. of Anthropological and Ethnological Sciences, 5th, Philadelphia, Pa. (Secretary, American Organizing Committee, International Cong. of Anthropology, National Acad. of Sciences–National Research Council, 2101 Constitution Ave., Washington 25.)

2–7. Laurentian Hormone Conf., AAAS, Mont Tremblant, Quebec, Canada. (Committee on Arrangements, LHC, 222 Maple Ave., Shrewsbury, Mass.)

4–5. Meteoritical Soc., 19th meeting, Bloomington, Ind. (C. W. Beck, Dept. of Geology, Indiana Univ., Bloomington.)

4–6. International Assoc. of Milk and Food Sanitarians, annual, Seattle, Wash. (H. L. Thomasson, IAMFS, Box 437, Shelbyville, Ind.)

4–7. American Physiological Soc., Rochester, N.Y. (M. O. Lee, APS, 9650 Wisconsin Ave., Washington 14.)

4–9. American Ornithologists' Union, annual, Denver, Colo. (H. F. Mayfield, 2557 Portsmouth Ave., Toledo 13, Ohio.)

4–11. International Geological Cong., 20th, Mexico, D.F. (Congreso Geológico Internacional, Calle Balderas 36, Despacho 302-A, Mexico, D.F.)

4–11. International Paleontological Union, Mexico, D.F. (H. E. Vokes, Johns Hopkins Univ., Baltimore 18, Md.)

5–7. Wyoming Geological Field Conf., 11th annual, Moran, Wyo. (K. W. Frielinghausen, Box 1571, Casper, Wyo.)

5–13. International Cong. of Applied Mechanics, 9th, Brussels, Belgium. (H. L. Dryden, Director, National Advisory Committee for Aeronautics, Washington 25.)

(See issue of 15 June for comprehensive list)

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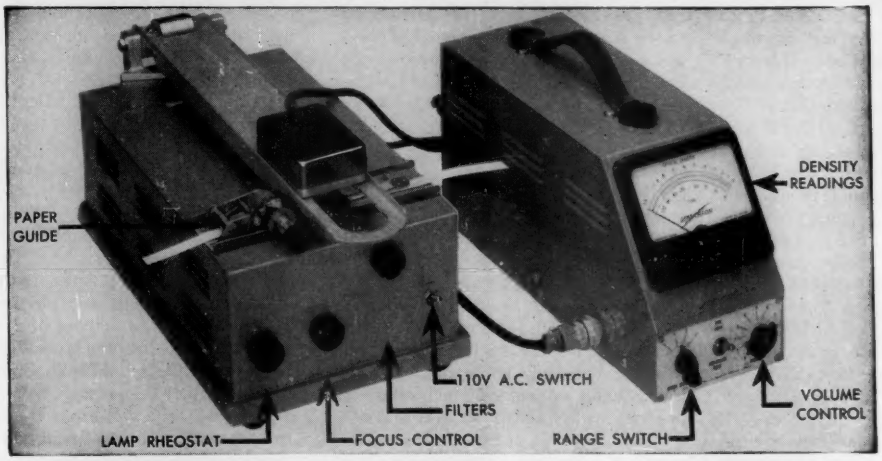

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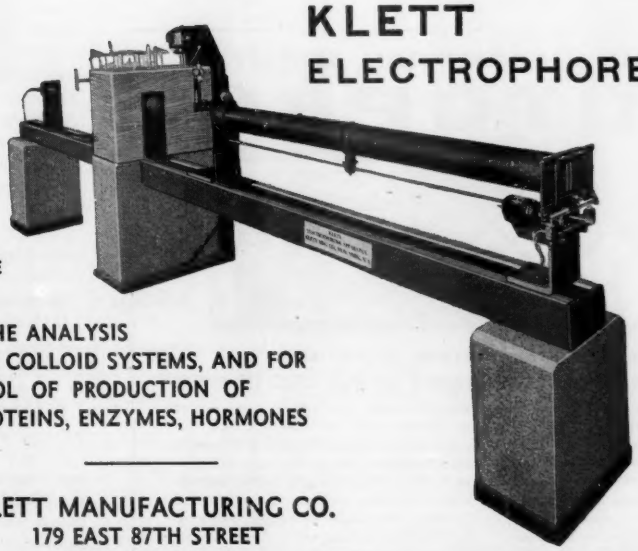

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Equipment News

■ PHOTOVOLTAIC CELLS, their construction, and characteristics are elucidated in a booklet recently published by International Rectifier. Basic circuits that are utilized in the applications for these self-generating photocells are included, as well as information on the suggested scope of such applications. (International Rectifier Corp., Dept. Sci., 1521 E. Grand Ave., El Segundo, Calif.)

■ LABORATORY CLAMPS that are made of a high-tensile, corrosion-resisting aluminum alloy with a tensile strength of 45,000 lb/sq in. and a melting point of 1100°F are described in an 8-page bulletin just published by Labline. Items are included on burette supports, utility clamps, extension clamps, 3-prong universal clamps, clamp holders, set-up frames, column clamps, and stirrers. (Labline, Inc., Dept. Sci., 3070 W. Grand Ave., Chicago 22, Ill.)

■ NOISELESS BLAST-BURNER may be utilized to work Pyrex glass up to 75 mm in diameter and Vycor glass up to 25 mm. Selection of flame sizes and temperatures is made by manipulating two valves and without changing the instrument's tip. Since the gases are mixed and the fuel is burned externally, the body of the instrument remains cool. The burner is mounted on a ball-and-socket joint and maintains a pilot flame. (Fisher Scientific Co., Dept. Sci., 418 Forbes St., Pittsburgh 19, Pa.)

■ VARIABLE REACTANCE INSTRUMENT for the 8200 to 12,400-Mcy/sec frequency range has been developed. Rated at 300-kw peak power in matched line, the instrument is used to introduce a standing wave of desired magnitude and phase in a waveguide, and it operates directly at any power level up to the breakdown power level of the waveguide. The magnitude of the standing-wave ratio in the line can be varied from 1.02 to 2.0 by means of a micrometer adjustment on the top carriage. The phase of the standing wave is separately variable by the movement of the carriage. Phase adjustment is greater than half the waveguide wavelength at the lowest frequency. The phase scale offers direct reading to 0.5 mm with vernier reading to 0.05 mm. (Narda Corp., Dept. Sci., Mineola, N.Y.)

■ STIRRER is designed for general laboratory stirring but can also serve as a shaker drive for Van Slyke apparatus and separatory-funnel extractions. The instrument operates with speeds from 100 to 1200 rev/min in 11 discrete steps. The motor is controlled by a tapped autotransformer. (Gerald K. Heller Co., Dept. Sci., 1 N. Carey St., Baltimore 23, Md.)

■ SILICONE RUBBER COMPOUNDS are described in a recently published 8-page brochure that also provides data on the properties of silicone rubber in general and its resistance qualities under a variety of conditions. (Raybestos Manhattan, Inc., Dept. Sci., Passaic, N.J.).

■ IMPREGNATED OPTOCHIN DISKS make possible a new test that provides differentiation between pneumococcus and streptococcus bacteria. The presence of pneumococci is revealed by a zone of inhibition. Results are read after 12-hr of incubation at 37°C. The disks may also be used for rapid identification of pneumococci in cultures in sputum, spinal fluids, and other organic fluids, and they remain stable when refrigerated. (American Hospital Supply Corp., Dept. Sci., Evanston, Ill.)

■ CARBON-14 COMPOUND, histamine (2-*ring*-C-14) dihydrochloride, has been added to the list of commercially available radioactive carbon compounds. This material is used in the study of amino-acid formation and metabolism, allergic reactions, and general body physiology. It is available at an activity of 1 mc/mmole. (Nuclear Instrument and Chemical Corp., Dept. Sci., 229 W. Erie St., Chicago 10, Ill.)

■ FRACTIONATOR collects liquid samples on a time basis that can be varied in four steps for the demonstration of changes in composition. Up to 30 test tubes are held under funnels in a Lucite disk that is rotated under the liquid source by a synchronous motor. (Edin Co., Inc., Dept. Sci., 207 Main St., Worcester, Mass.)

■ ULTRAMICROBALANCE for precise weighing of microgram quantities, has a sensitivity of 0.1 μg (or up to 0.001 μg on special order) and a load capacity that is 4 million times the sensitivity. The quartz-torsion balance can withstand shocks that would seriously damage a knife-edge balance. Quartz beam and torsion fibers are fused into a single unit. This construction makes possible positive duplication of weighings. The entire quartz system is gold-plated to aid in the dissipation of static charge. Pan holders are designed to support platinum pans, capillary tubes, or suspended objects. Space for tares is also provided. Special mountings to dampen vibration for reproducible weighings are not required. (Microtech Services Co., Dept. Sci., Box 121, Berkeley, Calif.)

■ ROTARY CONDENSER separates mixtures in the molecular weight range of 200 to 700. The new still features a glass column with an air-cooled rotary condenser and a dry-ice trap. During operation, distillate coming from the agitated surface of the pot is condensed by the rotating condenser and thrown to the upper, warm, evaporation surface where, under controlled conditions, it is re-evaporated and again condensed in the rotating condenser. Capacity of the still is 2 lit, and vacuum range is 0.1 μ-Hg. (Arthur F. Smith Co., Dept. Sci., Rochester 3, N.Y.)

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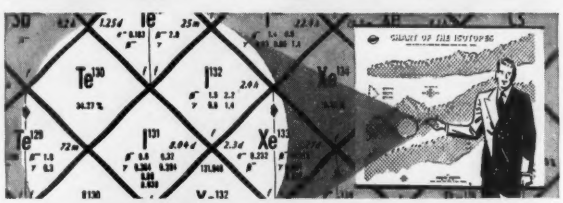

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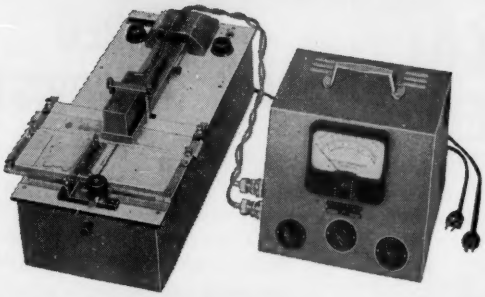

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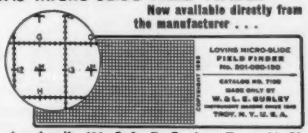

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Study of Adsorption at a Solution-Air Interface by Radiotracers	J. K. DIXON, C. M. JUDSON, and D. J. SALLEY, American Cyanamid Co., Stamford, Conn.
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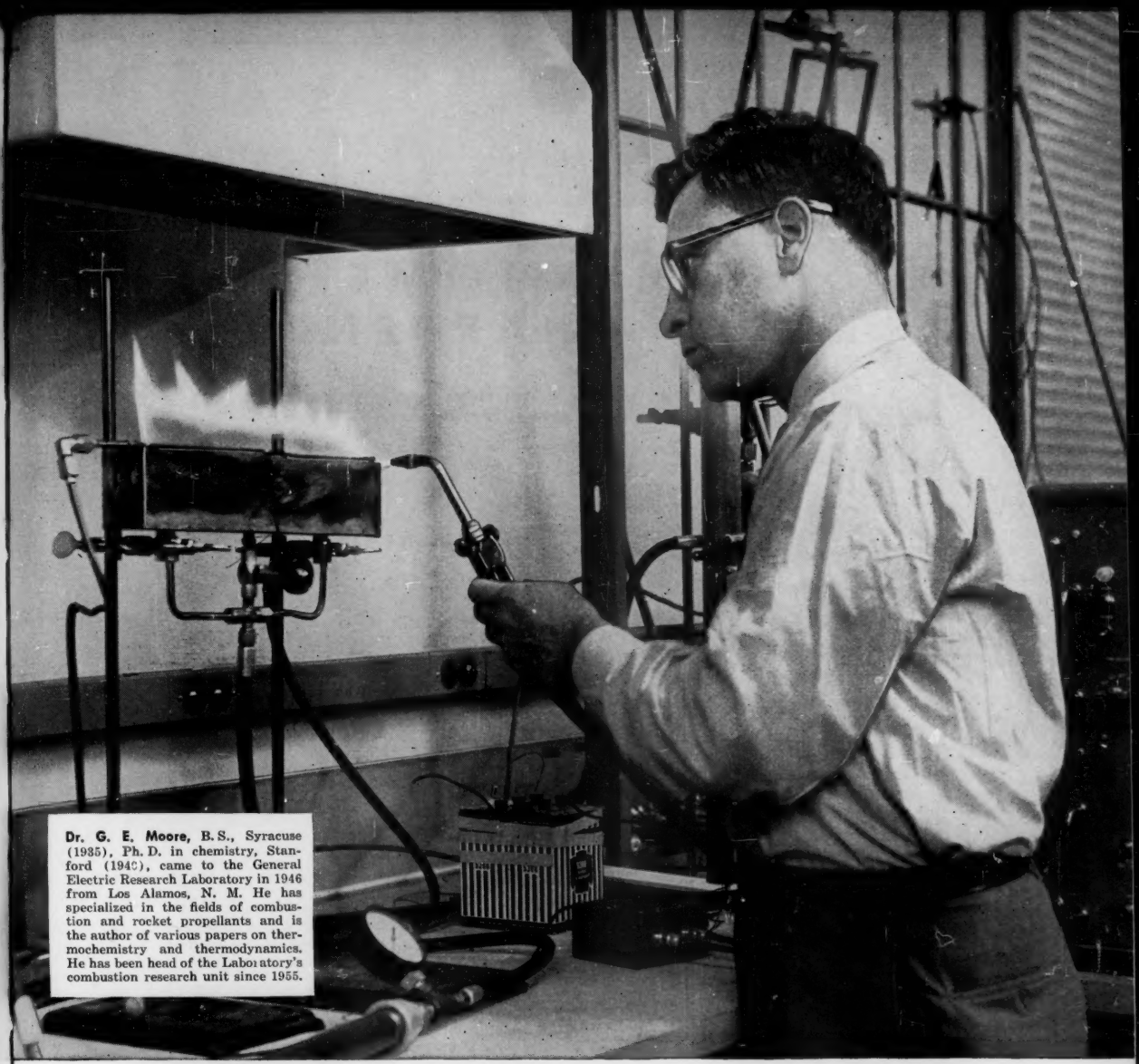

Dr. G. E. Moore, B.S., Syracuse (1935), Ph.D. in chemistry, Stanford (1940), came to the General Electric Research Laboratory in 1946 from Los Alamos, N. M. He has specialized in the fields of combustion and rocket propellants and is the author of various papers on thermochemistry and thermodynamics. He has been head of the Laboratory's combustion research unit since 1955.

Research for better rockets

General Electric's Dr. George E. Moore applies basic studies of combustion to development of propellants

Behind the use of rocket motors in such devices as guided missiles and earth satellites is a history of painstaking research into the fundamentals of *combustion.* Dr. George E. Moore's contributions to this comparatively new science have included calculations of the effect of combustion-chamber size and shape on rocket efficiency, innovations in the use of fuels, and new understanding of the general chemistry of rockets. He and a group of General Electric associates have devised a new type of "hybrid" motor—using both liquid and solid fuels—that is a model of simplicity and efficiency in rocket propulsion and promises to play a significant role in what is certain to be a big future for rockets.

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With electric motor drive and with *automatic* knife lifting and reversing device

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7203. Showing hood removed from knife mechanism.

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